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VOL. 15, NO. 1 March, 1940

THE QUARTERLY REVIEW
of BIOLOGY

THE NON-SPECIFICITY OF THE GERM-LAYERS

BY JANE M. OPPENHEIMER

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Eigentlich beginnt in jeder dieser drei Schichten eine eigene Metamorphose, und jede eilt ihrem Ziele entgegen; allein es ist jede noch nicht selbstständig genug, um allein das darzustellen, wozu sie bestimmt ist; sie bedarf noch der Hülfe ihrer Gefährtinnen, und daher wirken alle drey, obgleich schon zu verschiedenen Zwecken bestimmt, dennoch, bis jede eine bestimmte Höhe erreicht hat, gemeinschaftlich zusammen. . . .

Chr. Pander.

INTRODUCTION

PROBABLY the single set of facts that biologists who specialize in other branches of their science than embryology carry away in their store of general information is that describing the histological accomplishments of the germ-layers. The embryologists themselves as pedagogues are probably more dogmatic concerning these facts than concerning any other [the recent edition of the Brachet (1935) textbook is a welcome exception]. The fixed and simple concept as expressed in the germ-layer doctrine is easy to remember and accordingly has been gratefully retained for its usefulness as a rule of thumb.

Time and time again contradictions have found their way into the specialized literature of embryology but they have only rarely penetrated into general consciousness. Since the recent work in embryology has had important bearings on the problem, it seems well to review the field once more. The historical approach to the problem has been chosen simply because it is so interesting to trace through the dogged attempt of the human mind to cling to a fixed idea.

EARLY HISTORY

Up to the middle of the eighteenth century, the existence of the process of development was recognized, but its constituent mechanisms were quite unknown. Aristotle, Fabricius, Harvey and many others less illustrious had seen embryos or foetuses and had even watched them develop; they had seen in them the forerunners of adult structures, and had noted the appearance of some of these. How the structures were formed—what their source and what their material—was a question unaskable for many reasons.

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In the earlier days of embryology, before the Renaissance, unquestioning belief in a rigidly Aristotelian philosophy limited the explanation of all biological processes, development included, to the basis of a concoction of four humours. Even after the Renaissance, when this explanation had been abandoned in anatomy, it sufficed for embryology because no one could detect, with unaided eye, those developmental processes whose very existence defied suspicion until the invention of the microscope.

For some reason embryologists delayed using this instrument until a century after its introduction, and then, ironically enough, the results of its first employment denied the process of development. Malpighi, in perhaps the most famous error of biology, thought that he discovered the principal adult organs present in the unincubated egg. It was in the refutation of this error, that the possibility that there might be such a thing as a germ-layer was called into existence. Caspar Friedrich Wolff (1758; 1812) looked at the unincubated chick blastoderm and found that the organ rudiments were not yet present in it. He further found that later the gut and probably also the nervous system were formed by a process of folding of a layer of the stuff of which the blastoderm is composed.

Wolff, however, simply saw that the adult organs were not necessarily preformed in the unincubated blastoderm, but that some of them were formed later from layers of the blastoderm. It was Pander, however, student of Döllinger, who really elucidated what these layers were.

FIRST DESCRIPTION OF THE LAYERS

Christian Pander, in his two papers published in Würzburg in 1817, first described the trilaminar structure of the incubated chick blastoderm. [It was Pander who originally coined the word "blastoderm": "Because the embryo chooses this as its seat and its domicile, contributing much to its configuration out of its own substance, therefore in the future we shall call it *blastoderm*" (1817b, p. 21).] His own description of the three layers (1817a, pp. 5, 11–12) is better translated than paraphrased:

> At the twelfth hour the blastoderm consists of two entirely separate layers, an inner one, thicker, granular and opaque, and an outer one, thinner, smooth and transparent. The latter, because of its development and for the sake of greater accuracy of description, we may call the serous layer and the former the mucous layer. . . . There arises between the two layers of the blastoderm a third middle one in which the blood vessels are formed, which we therefore call the vessel-layer; from its origin events of the greatest importance subsequently occur. . . . Actually there begins in each of these three layers a particular metamorphosis, and each one strives to achieve its goal; only each is not yet sufficiently independent by itself to produce that for which it is destined. Each one still needs the help of its companions; and therefore all three, until each has reached a specific level, work mutually together although destined for different ends.

Pander not only recognized the layers once they were formed, but he also realized clearly that one layer was formed at the expense of another. He wrote elsewhere (1817b, pp. 26–27):

> What merits most attention is the composition of the blastoderm out of two layers. For before incubation this membrane consists of a single layer, made up of granules which cohere to each other by their own viscosity. As incubation progresses, however, there originates from this another layer, more delicate but firmer in structure, so that at a specific time the blastoderm can be divided by a fairly long maceration into two layers.

ELABORATION OF THE GERM-LAYER CONCEPT

Pander crystallized the germ-layer concept for the chick embryo. His friend and colleague, Karl Ernst von Baer, also a student of Döllinger's, extended it to

encompass all of vertebrate development, thereby laying down the fundamental bases for the study of comparative embryology.

Von Baer (1837, Bd. 2, S. 68) recognized the value of Pander's contribution; only in a way he reorganized it perhaps a trifle too assiduously, since he unjustifiably stretched Pander's three layers to four, breaking up the middle layer into two layers—roughly the equivalent of what we know as somatopleure and splanchnopleure:

> We can speak of an upper and a lower layer; the former we call the skin layer and the latter the mucous layer. The material that lies between the two clings partly to the upper layer and partly to the lower. In this way there gradually develop two inner layers, an upper and a lower. In the lower of the inner layers the granules become clear and dissolve into vesicles, and finally part of the contents of this layer begins to flow. It becomes a vessel-layer. In the upper the granules become darker; this becomes a flesh- or muscle-layer.

KARL ERNST VON BAER (1792–1876)

It seems hardly necessary to emphasize that von Baer's most significant contribution, so far as the germ-layers are

concerned, was the recognition of the fact that Pander's discovery for the chick was valid for all the rest of vertebrate development. This has been the basis of embryology from von Baer's time until today.

The question often arises as to what the status of embryology would be without the contribution of von Baer. It might conceivably be little different than it is, because of the insight of another investigator who had the misfortune, from posterity's point of view, to be a contemporary of von Baer. In 1825, several years before the publication of von Baer's treatise, Martin Heinrich Rathke, who had read Pander's paper, applied this author's observations on the germ-layers to the development of an invertebrate, *Astacus*, describing the splitting of the blastoderm into a serous and mucous layer which fit one inside the other "like the coats of an onion" (quoted in E. S. Russell, 1916, p. 208). As a matter of fact Rathke seems to have applied Pander's figurative vocabulary as well as his concept to the invertebrates, since he wrote, without anywhere in his paper referring to Pander: "After the blastoderm has divided into two particular layers, each of these layers proceeds by itself towards its final goal" (translated from Rathke, 1825; pp. 1094–5). So much was stated in the preliminary note. The final paper, which was published in 1829, described the layers more explicitly:

> One of them clings closely to the yolk and corresponds to the mucous layer of vertebrates, and is subsequently used for the production of the intestine and of a special yolk-sac. The other, on the other hand, is essentially comparable to the serous layer of the vertebrate, insofar as it . . . forms the body wall of the embryo, from which the different appendages as well as the central part of the central nervous system take their origin. A special and separate vessel-layer is never perceptible . . . [there is] more the idea of it than its actual presence. (Translated from Braem, 1895, S. 495.)

These words show clearly that Rathke saw the implication of Pander's discovery as well as did von Baer. He was able to transfer the analogy even to the Invertebrates. His work was less well known than von Baer's, probably principally because his generalizations were more on the embryological and less on the transcendental side. So far as their actual content is concerned, it would have made as solid a groundwork on which to build the science of embryology as the more celebrated *Scholia* of von Baer.

The significance of von Baer's concept was immediately recognized. In one way, however, it seemed almost a culmination rather than a new point of departure, and for many years the concept was accepted with only slight amplification and refinement.

The refining, very nearly completed by Robert Remak between 1850 and 1855, consisted of a double process: first, the interpretation of the germ-layers as composed of cells which were derived from the single cell of the original egg; second, the essentially correct demonstration that each of the germ-layers has a specific histological future. Remak recognized two primary germ-layers: (1) the upper, or sensory layer, subdivided into medullary plate and its derivatives, and the epidermic plate, and (2) the under layer subdivided into (2a) the trophic layer which gives rise to the alimentary canal and its derivatives, and (2b) the motorgerminative layer which furnishes peripheral nerves, muscle, blood vessels, connective tissue, sex glands, etc. Furthermore, this middle motorgerminative layer is separated into dorsal and ventral somite plates by the pleuroperitoneal cavity, which is the precise equivalent of what we know as the coelome. It is obvious that these are the precise facts of the germ-layer concept as

we recognize them today, with the exception of the one major error concerning the origin of the peripheral nerves.

GERM-LAYERS IN THE VERTEBRATE EMBRYO AND THE ADULT COELENTERATE

Even before Remak had published his book, one investigator was beginning to realize that the two so-called primary germ-layers formed as fundamental a part in the architecture of the adult coelenterate as in the molding of the vertebrate embryo, and he laid the foundation of what was subsequently to become the whole superstructure of phylogenetic and ontogenetic studies so extravagantly elaborated by the adherents of the evolution concept.

Huxley is credited with this discovery. He wrote, in a matter-of-fact manner, in a short paper "On the Anatomy and Affinities of the Family of the Medusae" (1849, pp. 414, 425):

> I would lay particular stress upon the composition of this (stomach) and other organs of the Medusae out of *two distinct membranes*, as I believe that this is one of the essential peculiarities of their structure, and that a knowledge of the fact is of great importance in investigating their homologies. I will call these two membranes as such, and independent of any modification into particular organs, 'foundation membranes'. . . . A complete identity of structure connects the 'foundation membranes' of the Medusae with the corresponding organs in the rest of the series; and it is curious to remark, that throughout the outer and the inner membranes appear to bear the same physiological relation to one another as do the serous and the mucous layer of the germ; the outer becoming developed into the muscular system and giving rise to the organs of offense and defense; the inner, on the other hand, appearing to be more closely subservient to the purposes of nutrition and generation.

In a way, it is almost surprising that this discovery had not been made earlier, in view of the fact that Rathke had so early noted that Invertebrates as well as Vertebrates were bilaminar in early development. Also, Cuvier, as Huxley knew, had remarked on the bilaminar structure of the Coelenterates. In speaking of the Tubularians, Cuvier wrote (1846, p. 557):

> Here the polyps do not form simple aggregations in which the individuals are distinct: but they are intimately united in such a way that they compose a more or less complicated individual which we call a compound polyp.
>
> Whatever way the compound polyp is composed, the alimentary or digestive cavity of each polyp opens into a common nutritive tube, into which flows, or is secreted, the nutrient fluid produced by the digestive processes of each polyp.
>
> The walls of the nutritive tube are formed by a double membrane, always intimately fused in this part of the compound polyp; the external corresponds to the skin; the internal is a continuation of the digestive portion of the alimentary cavity (of the individual polyps).
>
> The former, in the compound polyp, secretes from its external surface a tube or sheath, thin like parchment, or horny in nature. . . .

As a matter of fact, however, the investigator who came closest to anticipating Huxley's brilliant generalization was none other than von Baer himself. Von Baer (1837, Bd. 2, S. 67) early compared the primary germ-layers with the walls of the coelenterate, in the following statement:

> Yet originally there are not two distinct or even separable layers, it is rather the two surfaces of the embryo which show this difference, just as polyps show the same contrast between their internal digestive and external surface. In between the two layers there is in our embryo as in the polyp an indifferent mass.

The primary germ-layers of the Coelenterates were given their definitive names shortly after the publication of Huxley's paper. In a paper "On the Anatomy and Physiology of *Cordylophora*," Allman wrote in 1853 (p. 368): "All the hydroid zoophytes can be proved to consist essentially of two distinct membranes; to the external of these membranes I shall give the name of ectoderm, and to the internal that of endoderm."

In spite of its importance, the implications of Huxley's brilliant observation remained unnoticed for almost twenty years. Haeckel's *Generelle Morphologie*, for instance, published in 1866, makes no mention of the germ-layers. The dearth of progress is perhaps nowhere better shown than by a study of Huxley's own *Introduction to the Classification of Animals*, published in 1869, exactly 20 years after his first statement concerning the Medusae. In this book, the only statements concerning the germ-layers are: (1) that the Hydrozoa are separated into two layers of tissue, the ectoderm and the endoderm, (2) that the Actinozoa are likewise constructed of two membranes, ectoderm and endoderm, (3) that the author can confirm Remak's statement that the brain and spinal cord of Vertebrates are a result of the modification of the serous layer of the germ, and (4) that the serous layer of the germ helps to form the amnion in the chick embryo while the allantois is formed from neither mucous nor serous layer but from the intermediate stratum. In no case here does he mention any relationship between coelenterate ectoderm and endoderm on the one hand and embryonic serous and mucous layers on the other. In other words, although Huxley had appreciated the fundamental relationship between the body-layers of Invertebrates and the embryonic layers of Vertebrates, yet twenty years later he and all other investigators were still waiting to utilize the generalization in any way, even for pedagogic reasons.

Even at this early date, before the word mesoderm had even been coined, and before the obvious generalization had been made, the germ-layer concept became subject to distortion. In 1865 William His formulated his "archiblast-parablast" theory. This theory, based on a study of the extremely specialized teleostean development, claimed that the archiblast, composed of the three classical germ-layers, gives rise to all the embryo except the blood vessels and connective tissue which are furnished by the parablast. His's theory bore little lasting effect on the development of embryology, and fortunately was ultimately abandoned even by its author. But it gives perhaps the first example of the way in which the germ-layer theory has been distorted in the course of its development.

EVOLUTIONARY SIGNIFICANCE OF THE GERM LAYERS

In the same years when Huxley was issuing lectures on comparative anatomy that included the words ectoderm and endoderm only in discussion of the Coelenterates, and when His was worrying about the archiblast and parablast, a Russian investigator was making the observations that were most instrumental —partly because of their own inherent worth and brilliance, partly because of the fortunate time at which they were published—in effecting the bond between embryology and anatomy, and between the study of ontogeny and phylogeny.

Alexander Kowalewski, in the years 1867–71, found that all the invertebrate embryos he studied, and these were of many types, were formed of the same primary layers as the vertebrate embryos, and, furthermore, that in all of them alike the layers arise in the same fashion, the inner layer being produced from the outer by a process of invagination. Kowalewski's words can speak for himself more convincingly than we can speak for him (1867a, p. 3):

> The first change in the embryo [*Psolinus*, a holothurian] consists of an insignificant invagination which becomes visible at one pole of the egg, and whereby the whole embryo takes on a somewhat conical form. The invagination progresses gradu-

ally farther and after a few hours forms a deep sack. . . . A similar division of the cells of the embryo into two layers, an outer and a central one, I have also observed in many other animals, and especially clearly in the eggs of *Phoronis*.

Nineteen days later, when he presented his paper on "*Amphioxus*" (1867b, pp. 3, 5), the generalization had broadened considerably:

The embryo now consists of two sheets or germ-layers, the outer and the inner; we can therefore compare it with the embryonic anlage of the bird, mammal and turtle-egg, when these still consist of two layers. If we compare figure 15 of Reichert's paper on the development of the guinea-pig with our figures 8 and 9, the similarity between these two forms of development immediately strikes us. . . . The embryo quite agrees, even in the most insignificant details, with the embryo of the corresponding stages of *Phoronis*, of *Limnaeus*, of *Asteracanthion berylinus* Ag., of *Ophiura* and of *Echinus*, according to my own still unpublished observations; and if we leave the cilia out of consideration, our larva agrees also with the corresponding stage of *Sagitta*, of the Ascidians (*As. intestinalis* and *Phalusia mammillata*); if we consider that the segmentation cavity is filled with yolk, it resembles also the larva of *Escholtzia*, of *Cestum* and of *Sepiola*. In all of the embryos mentioned here the formation of the two laminae or layers proceeds in exactly the same way. . . . Thus the first formation of the embryo would be quite in agreement for all these different animals; only in the further changes do we see appear the differences which characterize the individual type.

And in 1869 (p. 29), he wrote in a paper on worms and arthropods:

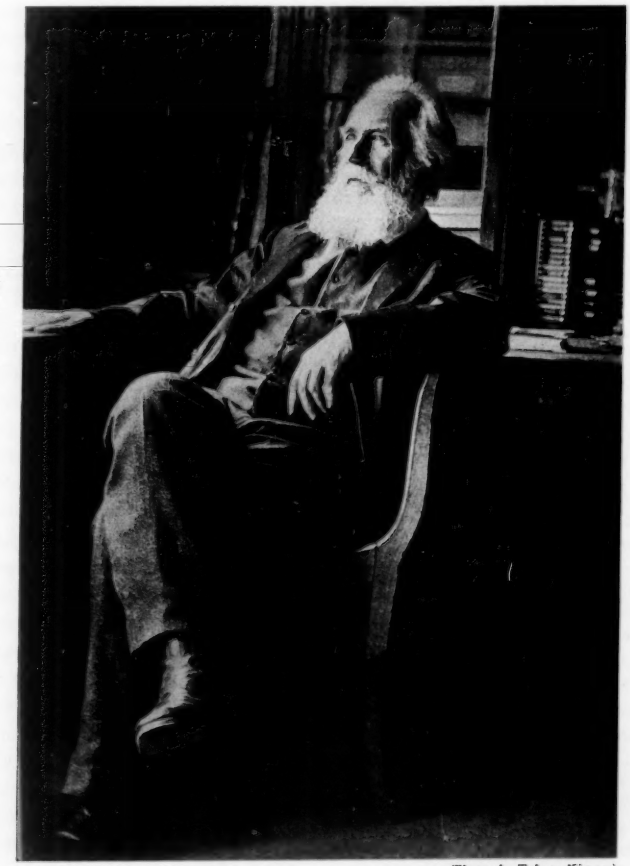
Now if we compare the development of the worms we have described with that of other animals, the analogy of the germ-layers of the worms with those of the Vertebrates, even in the details, astonishes us. The same two primitive layers which play the leading rôles in the development of the worm appear also in the Vertebrates; as in the one group so in the other the middle layer appears only later. The destinies of the layers and of the organ anlagen are in very great agreement even down to the individual processes.

Rathke's comparison of the embryonic germ-layers of Vertebrates and Invertebrates remained buried. Huxley's recognition of the relationship of the germ-layers in the adult coelenterate and the embryonic vertebrate, so strangely anticipated by von Baer, scarcely received comment for twe decades. But the researches of Kowalewski bore immediate fruit. By 1870 the scientific world was flaming with the debate on evolution that was kindled by the publication of Darwin's *Origin of Species*. The publication of Kowalewski's observations on the universality of the germ-layers and on their comparable origin in a multitude of forms made it possible to consider the evolution of the individual and the evolution of the race in the same light. The decade of the 1870's saw embryology adduced as a complete confirmation of the evolution-hypothesis, and the evolution of the race as an explanation *sine qua non* of the course of evolution or development of the individual.

The first significant attempt to relate phylogeny with ontogeny was that of Kleinenberg, who published in 1872 his monograph on the histology and development of *Hydra*, a paper dedicated, by the way, to Ernst Haeckel. In this the author found the coelenterate the perfect organism to represent the transition form from coelenterate to vertebrate embryo, and to represent the fundamental type on which all other forms are patterned and from which they are necessarily derived:

The low position of the Coelenterates in the system is perfectly understandable from their developmental history. Their type is determined by their maintenance of the fundamental spatial relationship of the germ-layers, and of their different layers in turn, to each other and to the external world. . . . The resultant great simplicity and uniformity of the whole body structure distinguishes the Coelenterates from all other animal groups: in the latter the definitive body arises through far-reaching histological segregations, but principally through manifold transformations and interminglings of the germ-layers,

with the result that these are scarcely recognizable at all in the completed organs, and only in vague outlines in the body as a whole. But if we follow the developmental history of these complicated organizations backwards, we arrive finally, in the Vertebrates and probably in all animal groups, to forms which correspond essentially to those of the type of the coelenterate is passed through as a developmental stage by all higher animals. The simple type of the coelenterate is the common ground form to which all the infinitely rich and manifold configurations of the animal body can be directly or indirectly referred. (Kleinenberg, 1872, pp. 87–88.)



(Photo. by Tokuzo Kimura)

ERNST HEINRICH HAECKEL (1834–1919)

Coelenterates. Now since these forms are necessary, but transitory, developmental stages upon which the specific type is built, while on the other hand among the Coelenterates the same forms, maintained unchanged, portray the type, so the conclusion is apparent that not only the developmental processes in all animals are identical up to a certain stage, but that even in individual development the transition of one type into another occurs, since the constant

In 1869 the terms ectoderm and endoderm had not yet been applied to describe the germ-layers of the embryo: in 1872 the terms were being used as they are now by Haeckel in Germany and in 1873 by Lankester in England. The term mesoderm was introduced by Huxley in 1871

(pp. 10–11 of the 1872 edition) in his *Manual of Anatomy*, and it was used by Haeckel (1872) in his monograph *Die Kalkschwämme*. Lankester's paper, published in May 1873, represents, according to its author, "part of a course of lectures commenced in the University Museum, Oxford, during Michaelmas term 1872." Haeckel's *Die Kalkschwämme* appeared in 1872 after Lankester's paper was drawn up but before it was published; whether he adopted Haeckel's terminology, or whether Lankester adopted his, or whether both independently used the same terminology, is not apparent. In 1873 Balfour and Lankester both were using the terms epiblast, mesoblast and hypoblast in place of the other terms. The history of terminology may be a futile study, but in the present case it is interesting since the men we have mentioned as changing the use of words simultaneously deflected the course of thought.

Lankester published in 1873 the preliminary and in 1877 the final communication in which he created a classification of animals based on their constitution into layers: All animals are homoblastic, diploblastic or triploblastic; the triploblastic forms are derived from the diploblastic through the Vermes; the planula, or the larva of the coelenterate, is the parent, phylogenetically speaking, of all diploblastic and triploblastic forms.

Haeckel (1872), in Germany, published simultaneously a similar theory destined to become of greater influence than Lankester's because of Haeckel's genius of expression. Haeckel's concept, in a way, was influenced heavily by the English school, partly because of Haeckel's blind acceptance of the evolution-doctrine and partly because of his deep personal affection for Huxley. The parent of all forms, in Haeckel's theory, is a two-layered sac similar to the bilaminar stage of all embryos described so skilfully by Kowalewski and known to us by Haeckel's term "gastrula." Haeckel wrote in 1872 (Bd. 1, S. 466–467) in the general part of his monograph on the Calcispongiae:

> In all of these representatives of the most varied animal groups the gastrula has exactly the same structure. In each case its simple monaxial oval body encloses a simple central cavity (gastral cavity) which opens through a mouth at one pole; in each case the thin wall of the cavity consists of two cell-layers, an inner layer of larger darker cells (entoderm, gastral layer, inner, trophic or vegetative germ-layer) and an outer layer of smaller generally ciliated lighter cells (exoderm, dermal layer, outer, sensory or animal germ-layer). I conclude from this identity of the gastrula in representatives of the most diversified animal groups, from the Sponges to the Vertebrates, according to the fundamental biogenetic law, that the animal phyla have a common descent from a single unknown stock form, gastraea, which is constructed essentially like the gastrula.

According to this theory, the gastrula, Kowalewski's bilaminar sac, produces all embryos; a similar *Urmutter* is therefore the necessary progenitor of all multicellular forms. Finally, the course of evolution of the embryo is step by step explained and *caused* by the evolution of the race to which the developing individual belongs. The development of the gill-slits in a mammalian embryo, to take a familiar instance, would be caused according to Haeckel necessarily and solely by the fact that in the course of evolution the ancestor of the mammal possessed gill-slits. One wonders how the promulgator of such a distorted doctrine of cause and effect could have been championed by the same Huxley who wrote: "Fact I know and Law I know: but what is this Necessity save an empty Shadow of my own mind's throwing?"

Haeckel was probably the transcendentalist par excellence of all biology. Equipped naturally with those rarely combined virtues, an aesthetic apprecia-

tion of a high degree and a passion for methodical terminology and organization, he produced in the gastraea theory a scheme of ideas as intricate and symmetrical as the figures of Radiolarians which he loved to portray with his pen. The most perfect example imaginable of fitting the facts to the theory, a beautiful intellectual feat, totally devoid of scientific value, his gastraea theory was the culmination of the early work on the germ-layers. Some of his contemporaries realized that phylogeny could not explain away ontogeny, and His (1874), for instance, vainly suggested and even attempted a study of the mechanical causes of development. But the beautiful unity of Haeckel's scheme was too seductive. Huxley and the English embryologists spent their days apotheosizing its author and looking at embryos only for the purpose of fitting the facts of ontogeny into the ideal of phylogeny.

Kleinenberg (1886, p. 2), who had nominated *Hydra* and the Coelenterates for the throne usurped by Haeckel's "gastraea," gave a succinct and vivid critique of the gastraea theory in his paper on the development of *Lopadorhyncus* which this time bore no dedication:

> The good in it (the gastraea theory) belongs to Huxley; what Haeckel has done to it is false, or perverted, or meaningless. It is false to trace all kinds of endoderm-formation back to the invagination of the blastoderm. It is perverted to substitute a problematical gastraea in the place of the coelenterate type. The value of Huxley's idea lay for the greater part in that it brought the early developmental stages of the higher Metazoa into immediate alliance with the completed forms of countless living Coelenterates. These latter are very diverse among themselves and still remain Coelenterates; that greater differences must exist between an adult coral and the larval form of an annelid is understandable, and will hinder no one from seeing the essential similarity of both organizations. In any case it was unnecessary to leave the Present and to descend into the Laurentian night to call forth as lean an animal-spectre as the gastraea. It is, incidentally, obvious that the gastraea is not able by itself to create the slightest hypothetical conception of the unknown origin of the Coelenterates, because the gastraea *is* nothing more than the coelenterate type schematized. Courageous hypotheses—daring conclusions—these almost always are of service to Science. But Schemata injure her if they bring existing knowledge into an empty and warped pattern, and claim thereby to give deeper understanding. Unfortunately the gastraea was not fertile, but it was strongly infectious; it has propogated itself as Neuraea, Nephridaea, etc. and is guilty of all the Original-animals, the Trochosphaera, the Trochophora, the Original-insect, and I know not what besides.
>
> Meaningless is the homologising of the gut-cavity of the higher Metazoa with the endoderm-cavity of the gastraea; a hole is a hole anywhere in the world. If once the equivalence of the walls is established, people will not need to worry their heads about the empty spaces inside.

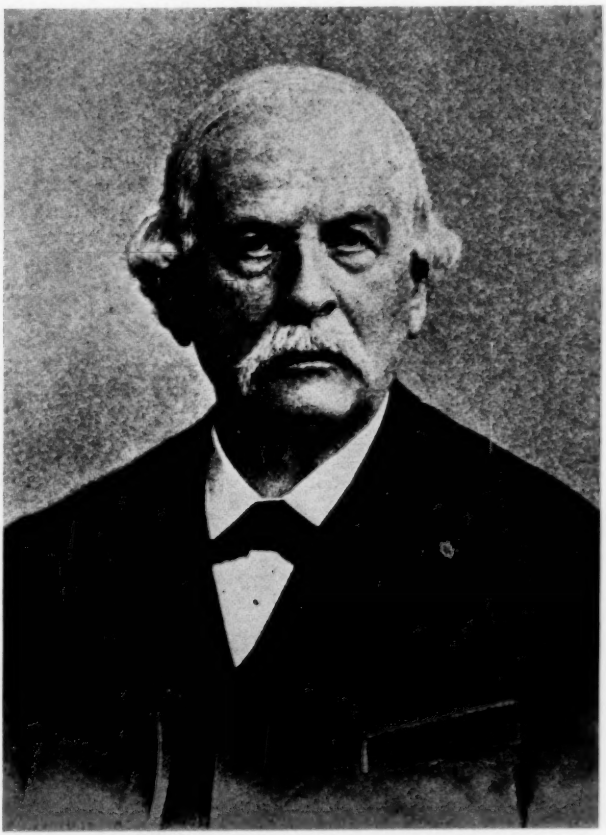
EARLY OBJECTIONS TO THE GERM-LAYER DOCTRINE

The first voices were raised against the germ-layer doctrine during the 1870's. Since those of Kölliker and the Hertwigs were loudest, and since the precepts of these authors epitomized those of their contemporaries, they may best be chosen as an example of the mode of reasoning of the opponents of the doctrine.

Kölliker (1879, '84, '89) questioned the validity of the doctrine principally from the histologist's point of view. While some of his reasoning now seems quaint, and some has since been invalidated by modification of the doctrine, some is still cogent. He claimed that the outer layer gives rise to many diverse types of cells—to epithelium, nervous cells, neuroglia, the pigment epithelium in the eye, etc. He added, however, basing his statement on his own observations and those of Leydig and Ranvier, that the outer germ-layer could give rise to smooth musculature in the case of the sweat-glands.

So far as the middle germ-layer is concerned, Kölliker claimed that this also

gave rise to too many diversified types of cell to have any meaning as a single entity. He emphasized that chorda is in some cases derived from the mesoderm and in others from endoderm—a fact without significance to us, who know



RUDOLF ALBERT VON KÖLLIKER (1817–1905)

that chorda and mesoderm each stem from a different group of cells, but which was at one time one of the most disputed facts of the whole doctrine. He adds further that so far as the hindmost part of the embryo is concerned, in a certain sense even the nervous system is formed from

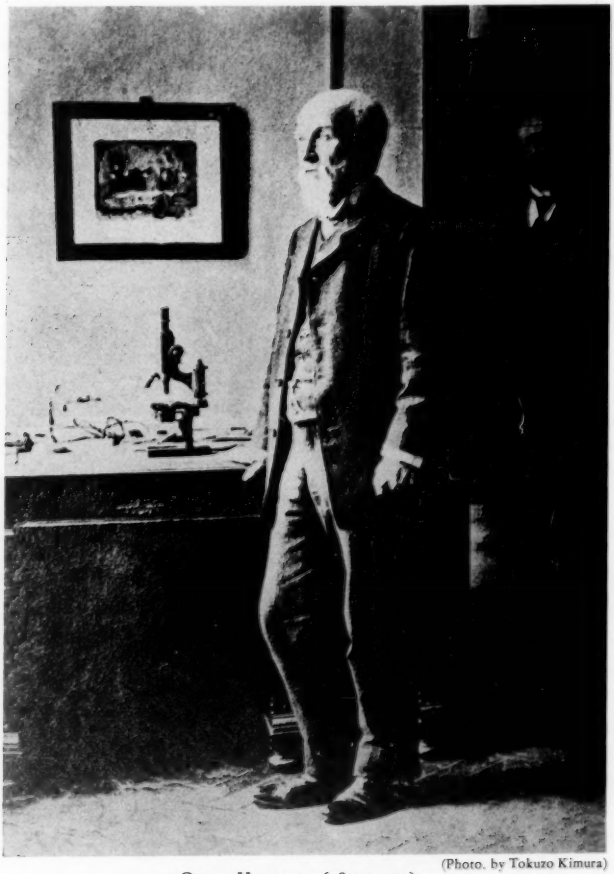
mesoderm, since the blastema from which all the hindmost structures are formed is predominantly mesodermal in origin.

So far as the endoderm is concerned, he erroneously claims that in *Amphioxus* it goes so far as to form somites and muscle and connective tissue, and that in many lower forms it produces chorda.

When Kölliker turns to a study of the Coelenterates, he claims, on the basis of his own work and that of other authors, that muscles and germ-cells, and in some cases even nervous tissue, are formed

sometimes from ectoderm and sometimes from endoderm. His evidence so far as the germ-cells are concerned is invalidated by the later discovery that these are derived from neither germ-layer but from cells which were probably segregated

> originally all the cells of the embryo, as they are produced by cleavage, are equivalent, so we may assert the proposition that all three germ-layers possess the potency and the capacity also for transformation into all tissues, but because of their specific morphological configurations they cannot everywhere manifest this power. (1879, S. 389.)



(Photo. by Tokuzo Kimura)

OSCAR HERTWIG (1849-1922)

during early development. However, his conclusions concerning the muscle are still valid. He concluded:

> In consequence of all these considerations the conviction is irresistably striking that the significance of the germ-layers is not histo-physiological but morphological: If we proceed from the fact that

While many of the facts on which Kölliker based his claims have been disputed, many of them still hold true, and as a matter of fact his reasoning does not suffer even when the evidence has been invalidated. Many of Köllik-er's conclusions were admittedly based

on evidence derived from the Hertwigs' studies on the Coelenterates. In 1878 the Hertwigs raised their first questions about the application of the germ-layer theory in a small monograph dealing with the histology of the Medusae. Inquiring, as had Kleinenberg, into the relationships of ectoderm and endoderm to mesoderm, they concluded that what they consider mesoderm in the Medusae is simply a product of the histological differentiation of ectoderm and endoderm. In their monograph on the Actinians, published a year later (1879) as the first of their definitive "Studies on the Germ-layer Theory," they continue their discussion, questioning the precise relationship of the two layers of the Coelenterates to the three of higher forms. On evidence that in some coelenterate groups germ-cells or musculature are derived from ectoderm and in others from endoderm, they conclude that "within particular animal groups the germ-layers have differentiated organologically inequivalently" (1879, p. 205). Furthermore they extend their generalizations, supporting themselves by evidence from other authors similar to that of Kölliker's outlined above, to include the other animal groups as well as the Coelenterates:

> The germ-layers are neither organological nor histological entities. It is not possible, if one knows the origin of an organ in one animal group, to carry over the result to all other animal groups. . . . Just as the capacity for transformation of individual cells, so is that of a germ-layer highly manifold, and it can express itself in the most different ways in the production of organs and tissues. (1879, pp. 216, 217.)

Here the Hertwigs have put their fingers on the whole solution of the germ-layer problem; but unfortunately they were not satisfied to stop here with a constructive contribution. Instead they chose to supplant the gastraea theory, which they had destroyed, with another theory which was not only unnecessary but even more far-fetched, if possible, than its predecessor.

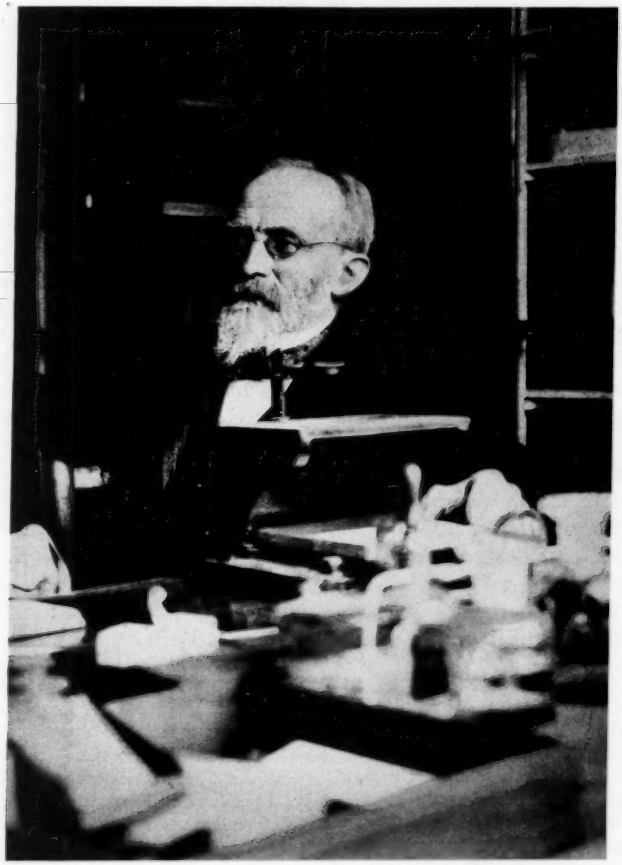
This they achieved by continuing the discussion of the difficulty arising from the attempts to homologize similar tissues developing from different germ-layers in diploblastic and triploblastic forms, and to find any uniformity whatsoever in the mesoderm which originates and develops so widely divergently in the various animal forms. Instead of following out their original suggestion that the germ-layers have wider capacities for differentiation than is usually recognized, they preferred to force the widely differing behaviour of mesoderm in different forms into a common pattern by their coelome theory (1881). According to this, the mesoderm (the mesoderm is in this paper first subdivided into mesenchyme and mesoblast; the latter term had been in use to describe the whole middle layer for many years) necessarily always arises from the endoderm, enclosing within its two layers part of the alimentary cavity as the "coelome" (Haeckel's name for the pleuro-peritoneal cavity of Remak). According to the Hertwigs (1881, p. 122):

> Ectoblast and entoblast are the primary germ-layers which originate by invagination of the blastula; they are therefore always the first formed and they can be referred back to a simple stem-form, the gastraea. . . . Parietal and visceral mesoblast, or the middle germ-layers, always originate later, and arise through a pouching or folding of the entoblast; . . . They bound a new cavity, the enterocoel, which may be considered a pinched-off diverticulum of the archenteron. As the two-layered animals are derivable from the gastraea, so are the four-layered from a coelome-form.

The whole theory, as an explanation of development, can probably never be better described than it has been by Braem (1895, p. 468) who wrote: "So the coelome theory, with all of its conse-

quence, presents one of the most glaring inconsequences to which the morphological conception of the germ-layers can lead."

This nice statement of Braem's formed part of a series of papers published in 1895 and entitled "What is a Germ-layer?", in which the author scrutinized the whole germ-layer doctrine from many angles. He raised the same doubts as to its validity as had the other investigators whom we have quoted; the only solution of the problem that he could offer was that the germ-layer theory was based purely on topography, while the homologies, or rather the analogies, of the layers could be comprehended only on a physiological basis.



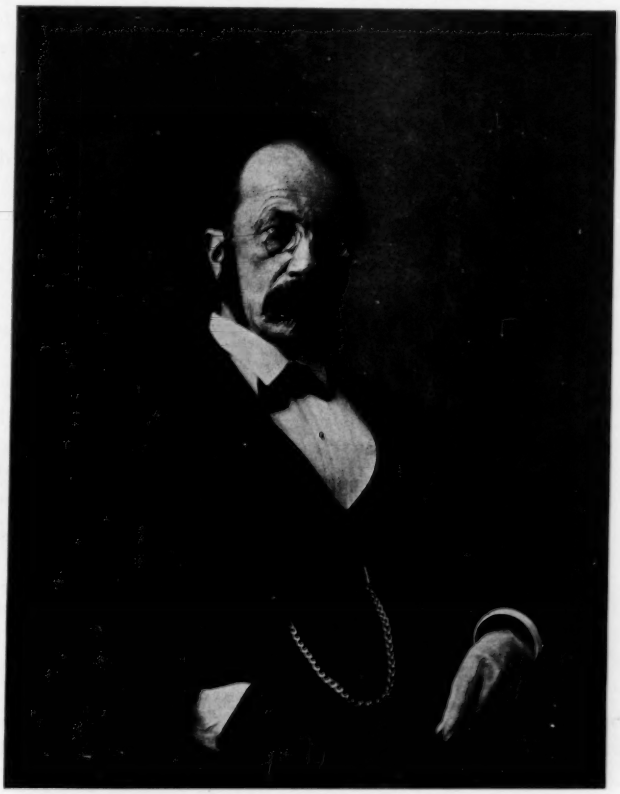
(Photo. by Tokuzo Kimura)

RICHARD HERTWIG (1850-1937)

THE GERM-LAYERS IN REGENERATION AND BUDDING

To be sure, this particular period saw the beginnings of the first attempt since His's to deal with the problem from a physiological point of view, or at least

from an experimental rather than a descriptive point of view. Perhaps the word *experimental* is dangerously used in this connection, since in one of the first important cases the experiment was performed by nature and simply observed and interpreted by the investigator. Hjort (1894a, b), in his study of bud-formation in the Ascidians, made the accurate and cogent observation that in *Botryllus* organs are not formed from the same germ-layers in egg-development and in budding. In development from the egg, for instance, the atrial chamber and the ganglion are each formed from the ectoderm in *Botryllus*; in the bud they are each derived not from the outer but from the inner layer. Hjort concluded that the layers of the bud are not germ-layers in the ordinary sense, but were composed of still indifferent material.



Wilhelm His (1831–1904)

The import of this discovery was at once appreciated as jeopardizing the validity of the doctrine. Heider (1897), in a paper that like Braem's was entitled with a rhetorical question never answered, "Is the Germ-layer Doctrine Shattered?", insisted that findings like those of Hjort were irrelevant so far as the germ-layer doctrine in embryology was concerned.

The doctrine, according to Heider, still holds for embryology, where it belongs, whether or not it holds true for the cases of budding and regeneration which are problems separate from those of embryology.

A more convincing argument, however, had been promulgated the year before by E. B. Wilson (1896) in a brilliant lecture at Woods Hole on "The Embryological Criterion of Homology." Wilson maintained that the conditions in bud-formation and regeneration were vitally significant for a comprehension of the processes in the embryo. He wrote (pp. 112–113):

> It may be urged that in regeneration and agamogenesis development is condensed and abbreviated so as no longer to repeat the phyletic development, and this is no doubt true. This explanation contains, however, a fatal admission; for if secondary modification may go so far as completely to destroy the typical relationships between the germ-layers and the parts of the adult, then those relationships are not of an essential or necessary character, and we cannot assume that the germ-layers have any *fixed* morphological value, even in the gastrula.

FIRST EXPERIMENTAL ATTACK ON THE PROBLEM

While philosophically speaking it may have seemed difficult to their contemporaries to choose between the interpretations of Heider and Wilson, even before their papers had been published the first experiment had been performed along the lines of the later ones which were finally to throw the balance to the side of Wilson. During 1892–93 Herbst subjected echinoderm eggs to treatment with a large variety of salts. He found that lithium had a specific effect on their development, namely the production of exogastrulae and entogastrulae in which the amount of endoderm in the embryo is greatly increased at the expense of the ectoderm.

> In figures 11, 6, 12–14, there thus occurs a gradual increase of endoderm, and hand in hand with it a successive reduction of ectoderm. In figure 13 the latter is present only as the small button labelled *ga*, and in figure 14 it is no longer present at all; here the whole blastula wall has been transformed to endoderm (1893, p. 144).

Herbst appreciated the implication of his results; not so did his contemporaries who did not wish to. Heider, for instance, in the paper referred to above, mentioned the lithium-embryos only as a possible explanation of how in the production of endoderm in Coelenterates the processes of multipolar migration and delamination might have been derived from polar migration.

THE PATHOLOGISTS AND THE GERM-LAYER DOCTRINE

Indeed the main body of embryologists (cf. Sedgwick, 1910) went their way, promulgating the germ-layer doctrine and attempting always to support and strengthen it. One other group of scientific investigators discussed the problem avidly: the pathologists, who were seeking panaceas to solve the atypical growth problem. Some of them, perhaps most notably Marchand (1899–1900), unsuccessfully sought the aid of the germ-layer doctrine. They contributed more to the embryologists, however, than they received from them, since they could furnish evidence both pro and con. Not the most influential, but perhaps one of the most interesting results of the cooperation between pathology and embryology, was the prophecy of the experiment, and its results, which have been most instrumental in abolishing the notion of the fixity of the layers. C. S. Minot in a paper on the embryological basis of pathology wrote, in 1901 (p. 485): "It seems quite probable to me that the cells of the germ-layers are at first quite indifferent, so that if it were possible to graft a young mesodermal cell on to the

ectoderm or endoderm, it would become a true ectodermal or endodermal cell, as the case may be." A similar experiment, performed by Mangold a quarter of a century later, has been considered one of the crucial experiments in the demonstration of the non-specificity of the germ-layers. discuss in this connection the results of the work on vertebrate embryos.

The interpretation of the experiments on the germ-layers of the Vertebrates was facilitated, in fact made possible, by the background work of Vogt (1925) who charted out on the amphibian blastula,

HANS SPEMANN (1869-)

MODERN EXPERIMENTAL WORK

1. Vertebrates

The turn of the century saw the embryologists change their method of attack from observation to actual operative manipulation. The capacity of the germ-layers for differentiation could now be tested as well as inferred. We may first by means of local vital staining, the precise locations of the areas later to become chorda, mesoderm, gut, epidermis and nervous system. Once the position of these cell-groups before gastrulation was known, their behavior in unusual positions, or in isolation, could be appreciated.

Perhaps the most far-reaching results on

the activity of the germ-layers, established experimentally, were those which demonstrated the influence of the lower invaginated layers of the amphibian embryo on the differentiation of the overlying ectoderm. Spemann had, in 1918, as is well known, noted the power of transplanted dorsal lip of the blastopore of the amphibian gastrula to induce the formation of a new embryo from presumptive epidermis; in 1924, in an investigation carried out with the collaboration of Hilde Mangold, similar experiments were performed using hosts and donors of different species whose tissues were sharply distinguishable from each other in sectioned material. From the results of this experiment it became apparent that the medullary plate in the induced embryo was formed by the host, while the underlying gut, chorda and mesoderm were furnished in part by the grafted dorsal lip. This result, and others of Spemann's (1918) from experiments in which presumptive epidermis was exchanged with presumptive medullary plate, or in which areas of medullary plate and mesoderm of the neurula were rotated through 180° (1912), suggested that the lower layers were somehow responsible for the differentiation of the upper. This was crucially and definitely demonstrated by Marx, who found, in 1925, that a piece of already invaginated archenteron roof, implanted into the blastocoele cavity, induced the formation of medullary plate from presumptive epidermis. Subsequently Bautzmann (1926, '28) was able to show by similar transplantation experiments that both presumptive chorda and presumptive mesoderm display the power of inducing the overlying epidermis to differentiate medullary plate.

All of these transplantation experiments suggest immediately the interpretation that the underlying layers, particularly mesoderm and chorda, as the inducing system (to use a term later introduced), are somehow inherently different in their capacities than the responding system of the overlaying ectoderm. This interpretation has been in one way borne out by results of explantation experiments, and by the production of amphibian exogastrulae. When amphibian embryos, especially axolotls, are treated with appropriate salt solutions, the mesoderm, endoderm and chorda roll outwards instead of inwards, with the result that the ectoderm remains simply an empty bag. In such exogastrulae, the mesoderm and endoderm and chorda self-differentiate to form somites, gut and notochord histologically quite typical of the normal embryo; the ectoderm, on the other hand, deprived of the proximity of these layers, forms only epidermis and never nervous system (Holtfreter, 1933).

Similarly in explantation experiments, in which isolated parts of the amphibian gastrula are cultured in salt solutions, as shown by Holtfreter's (1938 a, b) masterly work, isolated ectoderm fails to differentiate nervous tissue; it forms only epidermis when deprived of influence of cells of the other layers. The presumptive endoderm, whose rôle has been least clearly analyzed in the transplantation experiments, when isolated in salt solution self-differentiates only endodermal structures.

Cells of the presumptive chorda and mesoderm regions, in contrast to those of the other two germ-layers, readily overstep the classical bounds of the germ-layers, and when isolated in salt-solution can self-differentiate, or induce from their own cells, according to interpretation, medullary plate and epidermis on the one hand, and gut on the other, in addition to forming the usual mesodermal structures.

If the experiments are carried out, however, by placing the isolates *in vivo* rather than *in vitro*, the ectoderm and endoderm can accomplish far more than in salt solution. This has been demonstrated by Kusche (1929) and Bautzmann (1929), who placed the tissues into the empty orbital cavity of older larvae, and Holtfreter (1929) who implanted them into the abdominal cavity of amphibian larvae. In these cases, presumptive ectoderm formed not only medullary tube, but also notochord and muscle, and presumptive endoderm was able to differentiate notochord. Here where the cells were subjected to influences of highly complex organic nature, even ectoderm and endoderm were able to differentiate structures normally formed by the other germ-layers. The nature of these external influences and of their action is unknown. But their effect is sufficient to demonstrate that the differentiating cells themselves have a wider capacity for diversification than the other experiments had suggested.

These are by no means the only clear-cut experiments demonstrating the variety of potencies expressible by the cells of the amphibian gastrula. Mangold had in 1923 performed the experiment postulated twenty years before by Minot and thus dealt the germ-layer doctrine one of its most mortal blows. He found that presumptive ectoderm formed somites, chorda, pronephros, etc. when grafted into appropriate regions. Furthermore, Bruns (1935) showed that when large defects were made in the presumptive ectoderm of amphibian gastrulae, the medullary plate could be formed from presumptive mesoderm. Lopaschov (1935) also showed that when several explants of presumptive mesoderm fused they frequently produced medullary plate. Lehmann (1937) has shown that lithium has a specific mesodermizing effect on presumptive notochord material in the amphibian gastrula.

Similar demonstrations have been made on other forms than amphibians. Hunt (1937 a and b) has shown for the chick that after removal of the presumptive endoderm the mesoderm can form gut, and indeed that even normally it makes a large contribution to the formation of this structure. It also has been shown for the fishes (Oppenheimer, 1938) that presumptive mesoderm can differentiate nervous structures under certain conditions.

The perfectly valid objection can be raised that in all the cases enumerated the cells whose accomplishments are being studied have been observed acting under highly abnormal conditions, and though it does not necessarily invalidate the results of the experiments, this is to a large extent true. There are, however, some striking cases in vertebrate development where, even in the intact embryo, cells of one germ-layer form structures usually contributed by the others. One of these, touched on by Kölliker (1884), is in tail-formation in the Vertebrates. Kölliker had postulated that all the structures in the tail of a vertebrate embryo were formed from a blastema that was primarily mesodermal in origin. Such is not precisely the case in the amphibian embryo, but the actual conditions as they are support Kölliker's conclusion very strongly. The notochord of the amphibian embryo's tail is formed as a prolongation of that of the trunk. The tail somites, however, as demonstrated conclusively by the vital staining experiments of Bijtel (1931), are formed by the posterior portion of the medullary plate itself. Here is a clear-cut case in normal development where typically mesodermal structures are formed by cells ectodermal in origin.

Another such case is shown by the

behaviour of the cells of the neural crest. The history of the work on this problem has been fully reviewed by Harrison and therefore need only be summarily discussed here. [All references concerning the neural crest cited here may be obtained from Harrison's (1938) paper.] The neural crest, as every one knows, is clearly an ectodermal derivative in the sense of the germ-layer doctrine. However, it was demonstrated even in the last century that it furnished mesenchyme (Kastschenko and Goronowitsch), and, in 1894, it was given, together with the branchial sensory placodes which make a similar contribution, the name of mesectoderm, by von Kupffer. In 1897 Miss Platt showed, on morphological grounds, that the branchial skeleton was derived from mesectoderm. The recent experimental evidence has demonstrated that the neural crest unquestionably forms the Schwann sheath-cells, the spinal ganglia, part of the cranial ganglia, the branchial skeleton, mesenchyme, melanophores and xanthophores, possibly the ganglia of the sympathetic nervous system, and probably the pia-arachnoid membranes.

2. *Invertebrates*

Such varied accomplishments of the germ-layers are characteristic not only of the vertebrates, but of invertebrates as well. Probably as many single isolated cases could be enumerated for the Invertebrates as have been for the Vertebrates, but here we shall confine our remarks to two groups.

One of the most clear-cut cases imaginable of the transformability of the germ-layers has been presented by Penners (1926, '37a and b, '38) in his beautiful studies of the development of *Tubifex*. The *Tubifex* egg, as described by Penners (1924) exhibits the spiral cleavage characteristic of the annelid egg. It is further characterized by the presence at its animal and ventral poles of a special "pole-plasm" which passes during cleavage into the cells 2d and 4d which give rise respectively to the ectodermal and mesodermal germ-bands of the embryo. If the pole-plasm is eliminated or divided the cells 2d and 4d and subsequently the germ-bands fail to form or are doubled, as the case may be. Penners (1926) showed that if 2d or 4d were excluded from development, ectodermal or mesodermal germ-bands respectively failed to form; each type of germ-band, however, could differentiate apparently normally in the absence of the other (i.e. when 2d was removed and 4d left intact or vice versa). Later (1937a) he performed similar experiments, allowing the worms to develop to late stages, and the results here were extraordinarily interesting. In the absence of the ectodermal germ-bands, the mesoderm can later form all the organs usually formed by the ectodermal—central nervous system, circular musculature, lateral line, and the ectodermal portion of the seta-sacs. If, however, the source of the mesodermal germ-bands is removed and the ectodermal left intact (Penners, 1937b) the organs normally formed by the mesoderm are not replaced. It is nevertheless extremely interesting and important that in a form characterized by a relatively highly mosaic development the organs formed normally by one germ-layer can be formed by another.

The modern work on the Echinoderms has shown that in this form also the germ-layers have great adaptability. This was first suggested by Herbst's (1892–93) chemical experiments; it has been demonstrated repeatedly in defect- and transplantation experiments. The Rünnstroms (1918–19) showed, for instance, that animal halves of a holothurian egg, containing only presumptive ectoderm, could

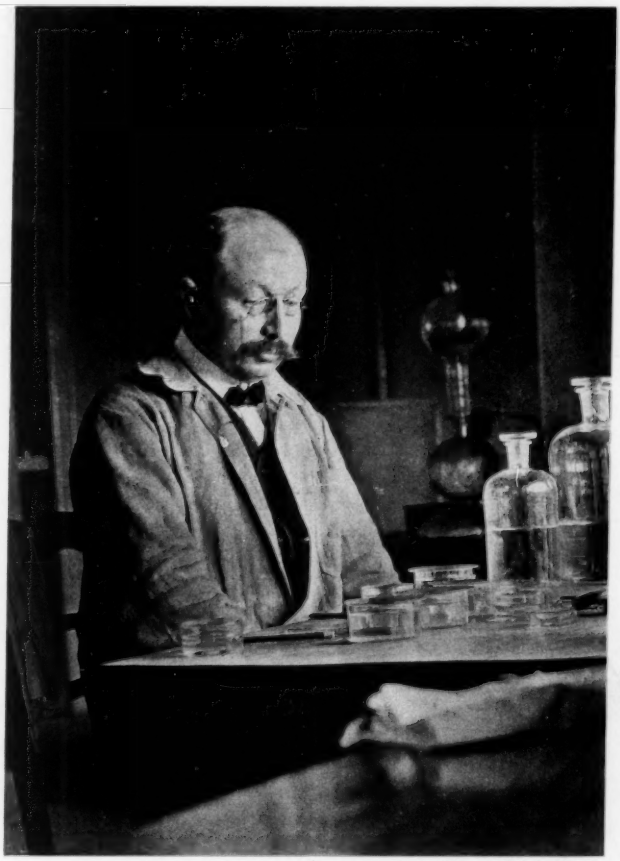
differentiate the coelome which is normally formed by mesenchyme, and subsequently Hörstadius (1928) has shown that coelome may be formed in regeneration by ectoderm, endoderm or mesoderm. Recently the chemical and defect- and transplantation experiments have been extended, and they have been amplified and reinterpreted in the light of physiological studies on the developing egg and its parts in such a way that our picture of the developing echinoderm egg is as complete as any we have in embryology.

In the early defect-experiments, Driesch (1891–92, 1892–93, 1900) erroneously supposed all the parts of the developing echinoderm to be totipotent. This problem was clarified by Hörstadius (1928, '35) who showed that isolated animal halves of eggs, which contain only presumptive ectoderm, cannot gastrulate or form endoderm, while isolated vegetal halves can gastrulate and form plutei; sometimes the plutei have an overabundance of endoderm, and sometimes the isolated vegetal halves form exogastrulae with very large guts. The results of these experiments, and of similar ones involving smaller parts of the egg, gained significance with the publication of von Ubisch's (1933) paper which demonstrated on the basis of vital staining experiments the precise normal rôles of the various portions of the egg. The animal half of the egg, consisting at the 32-cell stage of a dorsal group of 8 cells (an^1) and a ventral group of 8 (an^2), forms the ectoderm of the dorsal surface of the pluteus. The vegetal half is divided at the 64-cell stage into a dorsal ring of 8 cells (veg^1) which forms aboral ectoderm, a more ventral ring of 8 cells (veg^2) which forms the endoderm, and at its most ventral pole the micromeres which form the mesenchyme. Driesch (1893) knew that the micromeres formed the mesenchyme, and all the workers previous to von Ubisch appreciated that the animal pole represented presumptive ectoderm. The main important point demonstrated by von Ubisch was that the upper part of the vegetal half also contained presumptive ectoderm.

The transformability of the germ-layers has been fully demonstrated by Hörstadius (1935) in his ingenious experiments of separating and recombining the cells whose normal behaviour is well known. He has shown, for instance, that when veg^2, which comprises the presumptive endoderm and normally forms gut, is eliminated from development, a normal pluteus results whose gut is formed by veg^1 which is composed of the presumptive ectoderm for the aboral surface. If both veg^1 and veg^2 are eliminated, again a normal pluteus forms whose gut is made by ectoderm of the animal half of the egg. In both of these cases the micromeres are considered to induce the ectoderm to become endoderm; but no matter what the mechanism, the result is that presumptive ectoderm forms endodermal structures. Similarly, micromeres implanted into the animal pole of whole eggs induce the formation of accessory gut from presumptive ectoderm. Entodermizing of presumptive ectodermal material occurs also when blastomeres are separated and recombined in such a way that the proportion of presumptive ectoderm to presumptive endoderm is far greater than usual; for instance, when a meridional half of an egg is combined with an animal half.

The transformability of the presumptive endodermal cells has also been shown by Hörstadius (1928). An isolated veg^2 group, for instance, is able to form ectoderm, though to be sure such ectoderm is slightly abnormal, as shown by the fact that it forms no stomodaeum nor ciliated band, and the skeleton, whose arrangement

depends on an interaction between ectoderm and mesenchyme, is somewhat abnormal. Driesch (1893) had known that eggs deprived of their micromeres could form normal plutei. Hörstadius demonstrated that in such eggs the secondary mesenchyme, which is derived from veg^2, is formed earlier than normal and serves to form the skeleton.



(Photo. by Tokuzo Kimura)

CURT HERBST (1866–)

Fortunately in the case of the echinoderm egg the physiological basis for the transformability of the germ-layers is being studied. Herbst (1892, '93) had shown that in whole eggs presumptive ectoderm could be caused to differentiate endoderm by the action of lithium. Von Ubisch (1929) showed that isolated animal halves, consisting only of presumptive ectoderm, which normally form no endoderm and fail to gastrulate, could accomplish both these tasks after treatment with lithium. Hörstadius (1936) has shown, by varying the length of treatment and by using parts of eggs isolated for varying

lengths of time, that the action of the lithium on the presumptive ectoderm is strikingly similar to that of implanted micromeres.

This work, beautiful in itself, has gained considerably in significance through the work of Lindahl and his co-workers (Lindahl, 1936; Lindahl and Stordal, 1937; Lindahl and Öhman, 1938). Lindahl suggested originally that in the whole egg the animal half, the presumptive ectoderm, exhibits a higher respiratory rate than the vegetal. Similarly, eggs "animalized" by chemical treatment have a higher respiratory rate than isolated vegetal halves. The action of lithium inhibits respiration, so that the presumptive ectoderm which is made to form endoderm simultaneously decreases its respiratory rate. Conversely, the presence of NaSCN or the absence of sulphate ion stimulates respiration and ectodermalizes presumptive endoderm. There are probably two systems of respiration involved at the two poles of the egg which act in a way synergistically, and the system at the animal pole is probably concerned with carbohydrate metabolism.

Lindahl and Holter (1938, unpublished) have been unable to find confirmatory evidence of Lindahl's original statement that the respiratory rate is higher in the animal than in the vegetal portion of the egg. In any case, no matter what the precise nature of the respiratory systems, the transformation of ectoderm to endoderm, and vice versa, has been shown definitely to have a metabolic as well as a morphological basis.

CONCLUSIONS

The only conclusion that can be maintained, as a result of all the experiments that have been enumerated, is that the doctrine of the absolute specificity of the germ-layers as enunciated in the last century must be abandoned. There are no doubt countless cases where in a specific animal form, the cells of one germ-layer cannot alone perform the functions characteristic of another, as for instance is the case with the ectodermal germ-bands of *Tubifex* (Penners, 1937b). There are however so many contrary accomplishments that even in the classical cases the differentiation of the cells must be based on other factors than their derivation from a specific layer. The nature of such factors probably varies in every instance. In some cases, such as the *Tubifex* egg, the constitution of the cytoplasm before cleavage plays an important rôle. In other cases, as with the echinoderm egg, the special metabolism of parts of the egg is of decisive importance. The precise topographical position of the cells is often significant, as in the case of amphibian development. The interactions of various cells one with another are of vital importance in controlling their differentiation in the vertebrates.

If so many factors other than the origin of the cells from particular germ-layers are of such vital importance, the question arises:—What is the significance of the germ-layers, if any? No matter what the precise factors involved, it seems certain that the precise location of a cell during gastrulation in many forms, or the precise origin of its cytoplasm from the egg in others, is in many cases correlated with the type of its later activity; therefore in a certain sense the germ-layers are of topographic significance, since the cells pass through them in their orderly progression of movements. In a teleological sense, formation of germ-layers seems to be the embryo's method of sorting out its constituent parts. The essential point is, however, that this method is not the only method that the embryo

can call upon to attain a specific end, and here as in many other cases in development the embryo can, when necessary, modify or abandon one method in favor of another. This point, anticipated by Kölliker (1879), as we have already shown, has been well stated in the Brachet textbook (p. 296): "In reality, the germ-layers, like the blastomeres, have an actual potentiality and a total potentiality; the former is what they normally become; the latter what they are capable of forming in addition under diverse natural or experimental influences."

The task of the student of the germ-layers then must become more than an attempt to discern how the embryo sorts its cells into one layer or another; it must become an elucidation of how the wide potencies of the germ-layers become subject to limitation to their normal accomplishment. Pander, who was first to describe the germ-layers, was fortunate and wise in emphasizing the interactions of the layers with each other. We should do well to emulate him, for only when we can more appreciate the manner and mechanisms of such interactions shall we understand the true significance of the germ-layers themselves.

[The portraits of Karl Ernst von Baer and Rudolf Albert von Kölliker are reproduced from Nordenskiöld's *History of Biology*, 1928, with the permission of the publisher Alfred A. Knopf, New York.]

LIST OF LITERATURE

Papers with comprehensive bibliographies on the germ-layer doctrine are marked with an asterisk.

Allman, G. J. 1853. On the anatomy and physiology of *Cordylophora*: A contribution to our knowledge of Tubularian zoophytes. *Phil. Trans. Roy. Soc. London*, vol. 143, pp. 367–384.

von Baer, K. E. 1828–37. Ueber Entwicklungsgeschichte der Thiere. Beobachtung und Reflexion. *Königsberg.*

Balfour, F. M. 1873. The development and growth of the layers of the blastoderm. *Quart. J. Micr. Sci.*, vol. 13, pp. 266–276.

Bautzmann, H. 1926. Experimentelle Untersuchungen zur Abgrenzung des Organisationszentrums bei *Triton taeniatus*, mit einem Anhang: Ueber Induktion durch Blastulamaterial. *Arch. f. Entw.-mech.*, Bd. 108, S. 283–321.

——. 1928. Experimentelle Untersuchungen über die Induktionsfähigkeit von Chorda und Mesoderm bei *Triton*. *Arch. f. Entw.-mech.*, Bd. 114, S. 177–225.

——. 1929. Ueber bedeutungsfremde Selbstdifferenzierung aus Teilstücken des Amphibienkeimes. *Naturwiss.*, Jahrg. 17, S. 818–827.

Bijtel, J. 1931. Ueber die Entwicklung des Schwanzes bei Amphibien. *Arch. f. Entw.-mech.*, Bd. 125, S. 448–486.

Brachet, A. 1935. Traité d'embryologie des vertébrés. Seconde édition revue et completée par A. Dalcq et P. Gerard. *Paris.*

*Braem, F. 1895. Was ist ein Keimblatt? *Biol. Centralbl.*, Bd. 15, S. 427–443, 466–476, 491–506.

Bruns, E. 1931. Experimente über das Regulationsvermögen der Blastula von *Triton taeniatus* und *Bombinator pachypus*. *Arch. f. Entw.-mech.*, Bd. 123, S. 682–718.

Cuvier, G. 1846. Leçons d'anatomie comparée. Tome huitième contenant les organes de la génération et des sécretions, avec une leçon complémentaire des organes de relations; par G. Cuvier et G.-L. Duvernoy. 2ième édition, corrigée et augmentée. *Paris.*

Driesch, H. 1891–92. Entwicklungsmechanische Studien. I. Der Werth der beiden ersten Furchungszellen in der Echinodermenentwicklung. Experimentelle Erzeugung von Theil— und Doppelbildung. II. Ueber die Beziehungen des Lichtes zur ersten Etappe der thierischen Formbildung. *Zeit. wiss. Zool.*, Bd. 53, S. 160–189.

——. 1892–93. Entwicklungsmechanische Studien. III. Die Verminderung des Furchungsmaterials und ihre Folgen (Weiteres ueber Theilbildungen). IV. Experimentelle Veränderungen des Typus der Furchung und ihre Folgen (Wirkungen von Wärmezufuhr und von Druck). V. Von der Furchung doppelbefruchteter Eier. VI. Ueber einige allgemeine Fragen der theoretischen Morphologie. *Zeit. wiss. Zool.*, Bd. 55, S. 1–62.

——. 1893. Entwicklungsmechanische Studien. VII. Exogastrula und Anenteria (über die Wirkung von Wärmezufuhr auf die Larvenentwicklung der Echiniden). VIII. Ueber Variation der Mikromerenbildung (Wirkung von Ver-

dünnung des Meerwassers). IX. Ueber die Vertretbarkeit der "Anlagen" von Ektoderm und Entoderm. X. Ueber allgemeine entwicklungsmechanische Ergebnisse. *Mitt. zool. Stat. Neapel*, Bd. 11, S. 221–254.

Driesch, H. 1900. Die isolirten Blastomeren des Echinidenkeimes. Eine Nachprüfung und Erweiterung früherer Untersuchungen. *Arch. f. Entw.-mech.*, Bd. 10, S. 361–410.

Haeckel, E. 1866. Generelle Morphologie. *Berlin.*

——. 1872. Die Kalkschwämme. Eine Monographie. *Berlin.*

*Harrison, R. G. 1938. Die Neuralleiste. Erganzheft. zum *Anat. Anz.*, Bd. 85, S. 3–30.

*Heider, K. 1897. Ist die Keimblattlehre erschüttert? *Schubergs Zool. Centralbl.*, Jahrg. 4, S. 725–737.

Herbst, C. 1892. Experimentelle Untersuchungen über den Einfluss der veränderten chemischen Zusammensetzung des umgehenden Mediums auf die Entwicklung der Thiere. I. Theil. Versuche an Seeigeleiern. *Zeit. wiss. Zool.*, Bd. 55, S. 446–518.

——. 1893. Experimentelle Untersuchungen über den Einfluss der veränderten chemischen Zusammensetzung des umgebenden Mediums auf die Entwicklung der Thiere. II. Theil. Weiteres über die morphologische Wirkung der Lithiumsalze und ihre theoretische Bedeutung. *Mitt. Zool. Stat. Neapel*, Bd. 11, S. 136–220.

Hertwig, O. 1881. Die Entwicklung des mittleren Keimblattes der Wirbelthiere. *Jena.*

*——. 1906. "Die Lehre von den Keimblättern." *In* O. Hertwig: Handbuch der vergleichenden und experimentellen Entwickelungslehre der Wirbeltiere. Bd. 1, Theil 1, S. 699–967. *Jena.*

——, and R. 1878. Der Organismus der Medusen und seine Stellung zur Keimblättertheorie. *Jena.*

——, and ——. 1879. Studien zur Blättertheorie. Heft I. Die Aktinien anatomisch und histologisch mit besonderer Berücksichtigung des Nervenmuskelsystems untersucht. *Jena.*

——, and ——. 1880. Studien zur Blättertheorie. Heft II. Die Chaetognäthen. Ihre Anatomie, Systematik und Entwickelungsgeschichte. *Jena.*

——, and ——. 1881. Studien zur Blättertheorie. Heft IV. Die Coelomtheorie. Versuch einer Erklärung des mittleren Keimblattes. *Jena.*

Hertwig, R. 1880. Studien zur Blättertheorie. Heft III. Ueber den Bau der Ctenophoren. *Jena.*

His, W. 1865. Die Häute und Höhlen des Körpers. *Basel.*

——. 1874. Unsere Körperform und das physiologische Problem ihrer Enstehung. *Leipzig.*

Hjort, J. 1893. Ueber den Entwicklungscyclus der zusammengesetzten Ascidien. *Mitt. zool. Stat. Neapel*, Bd. 10, S. 584–618.

——. 1895. Beitrag zur Keimblätterlehre und Entwickelungsmechanik der Ascidienknospung. *Anat. Anz.*, Bd. 10, S. 215–229.

Hörstadius, S. 1928. Ueber die Determination des Keimes bei Echinodermen. *Acta Zool.*, vol. 9, pp. 1–191.

——. 1935. Ueber die Determination im Verlaufe der Eiachse bei Seeigeln. *Pubbl. Staz. Zool. Nap.*, vol. 14, pp. 253–429.

——. 1936. Ueber die zeitliche Determination im Keim von *Paracentrotus lividus* Lk. *Arch. f. Entw.-mech.*, Bd. 135, S. 1–39.

Holtfreter, J. 1929. Ueber die Aufzucht isolierter Teile des Amphibienkeimes. I. Methode eine Gewebezuchtung in vivo. *Arch. f. Entw.-mech.*, Bd. 117, S. 422–510.

——. 1933. Die totale Exogastrulation, eine Selbstablösung des Ektoderms vom Entomesoderm. Entwicklung und funktionelles Verhalten nervenloser Organe. *Arch. f. Entw.-mech.*, Bd. 129, S. 670–793.

——. 1938a. Differenzierungspotenzen isolierter Teile der Urodelengastrula. *Arch. f. Entw.-mech.*, Bd. 138, S. 522–656.

——. 1938b. Differenzierungspotenzen isolierter Teile der Anurengastrula. *Arch. f. Entw.-mech.*, Bd. 138, S. 657–738.

Hunt, T. E. 1937a. The development of gut and its derivatives from the mesectoderm and mesentoderm of early chick blastoderms. *Anat. Rec.*, vol. 68, pp. 349–369.

——. 1937b. The origin of entodermal cells from the primitive streak of the chick embryo. *Anat. Rec.*, vol. 68, pp. 449–459.

Huxley, T. H. 1868–96. "The physical basis of life." *In* Method and Results, New York, 1896. (Lecture delivered in 1868.)

——. 1849. On the anatomy and affinities of the family of the Medusae. *Phil. Trans. Roy. Soc. London*, vol. 139, pp. 413–434.

——. 1869. An Introduction to the Classification of Animals. *London.*

——. 1871–72. A Manual of the Anatomy of Vertebrated Animals. *New York*, 1872 (*London*, 1871).

Kleinenberg, N. 1872. Hydra. Eine Monographie. *Leipzig.*

——. 1886. Die Entstehung des Annelids aus der Larve von *Lopadorhyncus*. Nebst Bemerkungen über die Entwicklung anderer Polychaeten. *Leipzig.*

VON KÖLLIKER, A. 1879. Entwickelungsgeschichte des Menschen und der höheren Thiere. Zweite ganz umgearbeitete Auflage. *Leipzig.*

——. 1884. Die embryonalen Keimblätter und die Gewebe. *Zeit. wiss. Zool.*, Bd. 40, S. 179–213.

——. 1889. Handbuch der Gewebelehre des Menschen. 6. umgearbeitete Auflage. Erster Band: Die allgemeine Gewebelehre und die Systeme der Haut, Knochen und Muskeln. *Leipzig.*

KOWALEWSKI, A. 1867a. Entwickelungsgeschichte des *Amphioxus lanceolatus*. *Mem. de l'acad. de St. Pétersbourg*, VIIe Série, T. 11, No. 4.

——. 1867b. Beiträge zur Entwickelungsgeschichte der Holothurien. *Mem. de l'acad. de St. Pétersbourg*, VIIe Série, T. 11, No. 6.

——. 1869–71. Embryologische Studien an Würmern und Arthropoden. *Mem. de l'acad. de St. Pétersbourg*, VIIe Série, T. 16, No. 12.

KUSCHE, W. 1929. Interplantation umschriebener Zellbezirke aus der Blastula und Gastrula von Amphibien. *Arch. f. Entw.-mech.*, Bd. 120, S. 192–271.

LANKESTER, E. R. 1873. On the primitive cell-layers of the embryo as the basis of genealogical classification of animals, and on the origin of vascular and lymph systems. *Ann. and Mag. Nat. Hist.*, Series 4, vol. 11, pp. 321–338.

——. 1877. Notes on the embryology and classification of the animal kingdom: comprising a revision of speculations relative to the origin and significance of the germ-layers. *Quart. J. Micr. Sci.*, vol. 17, pp. 399–454.

LEHMANN, F. E. 1937. Mesodermisierung der präsumptiven Chordamaterials durch Einwirkung von Lithiumchlorid auf die Gastrula von *Triton alpestris*. *Arch. f. Entw.-mech.*, Bd. 136, S. 112–146.

LINDAHL, P. 1936. Zur Kenntnis der physiologischen Grundlagen der Determination im Seeigelkeim. *Acta Zool.*, vol. 17.

——, AND L. O. Öhmann. 1938. Weitere Studien über Stoffwechsel und Determination im Seeigelkeim. *Biol. Zentralbl.*, Bd. 58, S. 179–228.

——, AND ÅKE STORDAL. 1937. Zur Kenntnis des vegetativen Stoffwechsels im Seeigelei. *Arch. f. Entw.-mech.*, Bd. 136, S. 44–63.

LOPASCHOV, G. 1935. Die Entwicklungsleistungen des Gastrulamesoderms in Abhängigkeit von Veränderungen seiner Masse. *Biol. Zentralbl.*, Bd. 55, S. 606–615.

*MANGOLD, O. 1923. Transplantationsversuche zur Frage der Spezifität und der Bildung der Keimblätter in der Entwicklung. *Arch. f. mikr. Anat. und Ent.-gesch.*, Bd. 100, S. 198–301.

MARCHAND, F. 1899. Ueber die Beziehungen der pathologischen Anatomie zur Entwickelungsgeschichte, besonders der Keimblattlehre. *Verh. d. deutsch. patholog. Gesellsch. München*, Jahrg. 2, S. 38–107.

MARX, A. 1925. Experimentelle Untersuchungen zur Frage der Determination der Medullarplatte. *Arch. f. Entw.-mech.*, Bd. 105, S. 20–44.

MINOT, C. S. 1901. The embryological basis of pathology. *Sci.*, N. S., vol. 13, pp. 481–498.

OPPENHEIMER, J. M. 1938. Potencies for differentiation in the teleostean germ-ring. *J. Exp. Zool.*, vol. 79, pp. 185–212.

PANDER, C. 1817a. Beyträge zur Entwickelungsgeschichte des Hühnchens im Eye. *Würzburg.*

——. 1817b. Dissertatio inauguralis, sistens historiam metamorphoseos, quam ovum incubatum prioribus quinque diebus subit. *Würzburg.*

PENNERS, A. 1924. Experimentelle Untersuchungen zum Determinations-problem am Keim von *Tubifex rivulorum* Lam. I. Die duplicitas cruciata und organbildenden Substanzen. *Arch. f. mikr. Anat. u. Entw.-gesch.*, Bd. 102, S. 51–100.

——. 1926. Experimentelle Untersuchungen zum Determinations-problem am Keim von *Tubifex rivulorum* Lam. II. Die Entwicklung teilweise abgetöteter Keime. *Zeit. wiss. Zool.*, Bd. 127, S. 1–140.

——. 1937a. Regulation am Keim von *Tubifex rivulorum* Lam. nach Ausschaltung des ektodermalen Keimstreifs. *Zeit. wiss. Zool.*, Bd. 149, S. 86–130.

——. 1937b. Abhängigkeit der Formbildung vom Mesoderm in Tubifex-Embryo. *Zeit. wiss. Zool.*, Bd. 150, S. 305–357.

RATHKE, M. H. 1825. Flusskrebs. Isis von Oken, Jahrg. 1825, Theil 2, S. 1093–1100.

——. 1829. Untersuchungen über die Bildung und Entwickelung des Flusskrebses. *Leipzig.*

REMAK, R. 1850–55. Untersuchungen über die Entwickelung der Wirbelthiere. *Berlin.*

RUNNSTRÖM, J., AND S. 1918–19. Ueber die Entwicklung von *Cucumaria frondosus* Gunnerus und *Psolus phantapus* Strussenfelt. *Bergens Mus. Aarbok. Naturv. Raekke*, 5; 9.

RUSSELL, E. S. 1916. Form and Function. A Contribution to the History of Animal Morphology. *London.*

SEDGWICK, A. 1910. "Embryology." *In* Encyclopedia Brittanica, 11th edition, vol. 9, pp. 314–329. *Cambridge.*

SPEMANN, H. 1912. Ueber die Entwicklung umgedrehter Hirnteile bei Amphibienembryonen. *Zool. Jahrb.*, Suppl. 15, pp. 1–48.

SPEMANN, H. 1918. Ueber die Determination der ersten Organanlagen des Amphibienembryo I–VI. *Arch. f. Entw.-mech.*, Bd. 43, S. 448–555.

——, AND H. MANGOLD. 1924. Ueber Induktion von Embryonalanlagen durch Implantation artfremder Organisatoren. *Arch. f. mikr. Anat. und Entw.-gesch.*, Bd. 100, S. 599–638.

VON UBISCH, L. 1929. Ueber die Determination der larvalen Organe und der Imaginalanlage bei dem Seeigelkeim. *Arch. f. Entw.-mech.*, Bd. 117, S. 80–122.

——. 1933. Formbildungsanalyse an Seeigellarven. *Naturwiss.*, Jahrg. 21, S. 183–186.

VOGT, W. 1925. Gestaltungsanalyse am Amphibienkeim mit örtlicher Vitalfärbung. Vorwort über Wege und Ziele. I. Methode und Wirkungsweise der örtlichen Vitalfärbung mit Agar als Farbträger. *Arch. f. Entw.-mech.*, Bd. 106, S. 542–610.

WOLFF, C. F. 1759. Theoria generationis. *Halle.*

——. 1812. Ueber die Bildung des Darmkanals im bebrüteten Hühnchen. Uebersetzt und mit einer einleitenden Abhandlung und Anmerkungen von Johann Friedrich Meckel. *Halle.* Originally published by Wolff as follows: De formatione intestinorum praecipue, tum et de amnio spurio, aliisque partibus embryonis Gallinacei nondum visis. Novi Comment. Acad. Sci. Impt. Petropol. vols. 12 and 13, 1768–69.

WILSON, E. B. 1894–96. The Embryological Criterion of Homology. Biological Lectures delivered at the Marine Biological Laboratory in the summer session of 1894. *Boston.*

THE FAUNA OF THE SOIL

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INVESTIGATIONS during the last twenty years have revealed a microcosm within the soil and its litter, which is as complex as that of fresh water. In contrast to the plancton, the geenton is specialized for slow movement through a dense granular medium.

Soil was originally conceived as composed of minute, irregular grains separated by interstices between the grains known as the pore-space. We now know this to be the least significant factor in soil structure. Of far greater importance is the maze of innumerable intertwining channels permeating every cubic inch of unplowed vegetated soil, channels formed and maintained by a host of animals common to that medium (67).

This fauna may be considered from two view-points: (1) the effect of its various members on the soil (a) in increasing channeling and therefore rain receptivity, i.e. in decreasing run-off and floods, (b) in increasing fertility and consequent more rapid growth of wood, (2) the interrelations of these animals through their feeding and breeding habits. The first is of economic value, the second is of sociologic interest.

EFFECT OF THE FAUNA ON THE SOIL

The simplest introduction to the animals is through a study of their effect on the substratum, which is also the source of food of all the life of field and woodland. The skein of interrelations will thereby become more apparent.

Included in the soil and an integral part of it, is the litter of plant parts and animal remains which form a covering over the surface of the mineral soil. This organic covering is most conspicuous as a carpet of dead and mouldering leaves which is gradually reduced by the action of bacteria, fungi, and a part of the fauna, to a litter of minute faeces which lies immediately over the mineral soil or is mixed into the mineral soil by various animals which may be conveniently referred to as *mixers*.

As affecting the mineral soil then, animals may be grouped under three heads: reducers (of litter), mixers (of organic residues and mineral soil), channelers (of the soil). To be of greatest value, soils must incorporate an adequate supply of all three groups.

Although forest soils are the most complex and bear the largest population, all other subaerial soils are similar, differing in being simpler and in having a more meager and a more specialized fauna. The richness of the fauna varies with the amount of available organic (chiefly plant) material. Where plants can grow, animals will thrive. By using as an example the soil fauna of the woodlands of the northeastern United States, the reader will envisage the framework of the populations of soils throughout the world. The number of species and the kinds of species change from one region to another, but their functions and interrelations remain the same. However, the influence of any one type of animal or of any one species varies greatly in its *intensity* locally. The present review will confine itself to the fauna of the mineral soil.

The deeper the organic covering, the fewer animals can reach the mineral soil. Thus, a layer of raw humus fifteen inches deep exercises a marked effect on the population in the mineral soil beneath it.

THE VERTEBRATES

The rôle of mammals

Mammals influence the soil in four ways: by manuring, trampling, mixing, and channeling.

All mammals manure the soil, though to varying extents, depending upon the size of the animal, its local abundance, and its food habits. Herbivorous animals defecate more than do carnivorous animals. The greatest dungers are the large herbivores, but the value of their contributions is lessened by the effect of their trampling.

Trampling and compacting of the soil is effected chiefly by the gregarious herbivores. This may be seen by anyone living in dairy country. Cows as well as many species of hoofed animals follow each other from place to place in single file. In this way paths are established. In fly time the paths lead through brush or clumps of bushes. When these bushes become frayed, trampled or otherwise inefficient in brushing off the flies, the cows start a new trail through other bush clumps. In this way their paths shift laterally. The daily passage of a herd of cows over a woodland trail compacts the soft, woodland soil so much that the level of the trail soon lies three to eight inches lower than the level of the forest floor. In open pastures, trails are shifted on the slopes so that an overgrazed pasture slope bears a net-like pattern of trails. This is as true of sheep as of cows.

In order to limit or reduce this trampling, it is necessary to limit the numbers of the larger hoofed animals per acre.

Many of the smaller mammals shelter and nest in the soil. For this purpose dens are excavated, the depth or extent of which varies with the species. In the east, woodchucks and chipmunks (22, pp. 238–245) are the best known and most typical soil diggers, though the habit is also shared by bears, otters, foxes, wolves, jumping mice (*Zapus* in meadows and *Napeozapus* in woodlands), and short-tailed shrews (*Blarina*). The effect of this digging is to throw mineral soil out over the organic layers. Most of these animals carpet their subterranean nests with dead leaves.

The burrows of woodchucks may be as much as twenty-five feet long with various galleries and nest chambers in the sides (90, p. 275). The nests are stored with dead leaves even though they have to be carried for many feet. It is problematical whether the woodchuck or the earthworm buries most leaves per annum per county.

Rabbit nests are about as big as a cocoanut, the bottom lying at least six inches below the level of the soil (17, p. 161).

However, the work of the larger diggers is so local, that its effect on the soil is of minor importance, except over a period of decades.

Blarina extensively tunnels the humus layers and builds a nest approached by many burrows usually occupying two levels, the nest being in the lower level and on the mineral soil. This complicated structure is usually built in a mound or hummock of organic material (decayed stump, log, or humus). The nest is furnished with a double handful or so of dry leaves. There may be ten to fifteen such nests per acre.

In addition to digging to make shelters and nests, some mammals dig to obtain food. The skunk makes deep narrow

holes in the earth by which it probes for insects (90, p. 105).

"During the succeeding half hour, it [a skunk] did not cover a space greater than three or four rods square, but literally every foot of this area was carefully inspected. Not content with rooting into every bunch of dead leaves, it dug dozens of holes, first plunging its sharp nose into the ground and then using its fore-feet, making the dirt fly. Its hole was only a few yards distant" (17, p. 124).

Large numbers of insect larvae, as white grubs (*Lachnosterna*), wire worms, alfalfa weevils, are eaten, for which they dig into the soil to a depth of two to four inches. During the early spring (April-May) field mice form a major share of the food although they have to dig to a depth of a foot to capture the mice (56).

Some animals dig for storage of food. The grey and fox squirrels dig small holes in the ground and deposit a nut or acorn in each cavity, carefully replace the soil, press it down, and cover the spot over with leaves. They may thus pepper the ground of their territory with such "plantings."

Soil tunneling is much more general and extensive than nest excavations, though possibly not as beneficial to the soil. Moles and voles are the most highly developed tunnelers among the mammals. In the east, the common mole (*Scalopus aquaticus*) pushes its tunnels through all fairly dry, sandy, or loose loam. It does not channel dry, compacted soil. At best its effect is to render good soil more loose and more open. It is a decided aid to percolation of rain water by breaking up the soil surface. Although any one tunnel or mole ridge may be very narrow (three to four inches) the mole is a very active animal and may throw up two hundred to three hundred feet of ridges every twenty-four hours during the growing season. They are also active during the winter. Furthermore, they are very useful in destroying June beetle larvae and other such noxious insects, especially when they become numerous. They do not eat bulbs and corms. Their diet of worms, however, is not to their credit. They should not be exterminated in woodlands unless their enemies are also exterminated. In wet soils, swamps and bogs the common mole is replaced by the star-nosed mole (*Condylura cristata*). Its burrows (1.3–3 inches wide and 1.5–2 inches high) extend along streams, ponds and lake shores, opening under water. There may be five per acre in swampy terrane. They feed from muck beds and stream bottoms on aquatic insects and worms.

The pine mouse (*Pitymys*) forms intricate and extensive burrows like those of the mole, in open wooded areas as well as in open land. Their caches extend to eighteen inches below ground. They do not range into the transitional zone. I have seen a forty-year-old white pine plantation with the upper two inches of the mineral soil completely honeycombed by this species.

The red-backed mouse (*Clethrionomys*) lives in similar burrows near the surface, especially in evergreen woodlands.

The meadow mouse (*Microtus*) makes very extensive burrows chiefly in meadows but also in marshes and even in swamps, storing them with vegetation.

Lemmings (*Synaptomys*) construct burrows about the edges of bogs, swamps, or even in drier areas of low cover.

The short-tailed shrews (*Blarina*) also tunnel in the surface soil, especially the humus, but only in soft earth and near water. As they tunnel chiefly in loose soil and humus, they are of doubtful value as soil channelers. The other shrews utilize the runways of other animals.

The influence of birds, reptiles and batrachians

Birds affect chiefly the litter by manuring and by scratching. Song sparrows, Juncos (17, pp. 71, 120), Lincoln sparrows (p. 140), red-polls (p. 225), fox sparrows and towhees are among the smaller scratchers. They certainly can make the leaves fly, but they do not materially affect the mineral soil. Pheasants and grouse, meadowlarks and others dig into the mineral soil with their bills to extract white grubs or tubers and the like, to a depth of an inch and a half or even two inches (teste A. A. Allen). Woodcock and snipe probe in soft soil to a depth of three inches.

Bank swallows excavate burrows (2.5 inches x 1.5 inches) to a depth of 36 inches below the overlying turf. Although a bank may contain thousands of such burrows, a few inches apart, most colonies comprise only one or two dozen pairs of birds. As they make new nests each season (88) their local effect in dislocating mineral soil is considerable. Since the nests (an enlargement of the burrow) are lined with straws, grasses and feathers the birds locally enrich the mineral soil for the vegetation above the bank. On the well-drained uplands where the soil is mostly hard-pan, shale, or rock this species is not found (36, p. 351).

Kingfishers are not so exacting in soil type and are therefore more generally distributed. Moreover, their burrows are 3½ inches in diameter, 4–8 feet deep, and terminated by a nest 8–10 inches in diameter and situated fairly close to the turf. Their organic contribution is phosphate-rich fish parts. Even if they are of more value in soil improvement than bank swallows, their effect is almost as local, and cumulative only over a long period of years (36, p. 138).

Although some birds on some oceanic islands honey-comb the mineral soil with their nest burrows, and on certain restricted tracts, birds overload the soil with their droppings, the effect of birds on soils generally is of a minor nature or extremely local. In our region their effect on soils is greatest on sand and gravel banks and terraces.

Of the three groups of reptiles, lizards, snakes and turtles, the latter are much the most important diggers. The box turtle and the wood tortoise are typical woodland species. They dig not only to lay their eggs but also to hole-up for the winter. Other turtles do likewise but their digging is confined to the borders of streams, ponds, marshes and swamps, or to sandy areas and sand and gravel banks. Such holes may be as broad as the turtle and nearly a foot deep (17, pp. 75, 129; 90, pp. 54, 65, 91, 105, 178, 179). All things considered the effect of turtles on the soil is noteworthy over a period of years in sandy places near water and in swamps.

Regarding batrachians: there is very little information on the digging and burrowing capacity of salamanders, though they are common in moist woodlands, especially where littered with stones. Toads dig out shelters in the soil, large enough to completely cover themselves. In suburban areas there may be a toad to each garden. In the White Mountains along the slopes above the Greeley Ponds a toad was disturbed nearly every linear rod. The unusual abundance here may be due to the deep humus which they can easily excavate. Their commonness about dwellings is due to absence of natural woodland predators. In woodlands with little humus and numerous predators toads are uncommon. Thus batrachians are of only minor importance in their effect on soils, especially on the

mineral soil—local concentrations excepted.

All the above-mentioned soil influents are to be encouraged as contributors in their own small way to soil improvement. It should be remembered that the effect of all these animals together (collective effect) over a period of time (cumulative effect) is a concrete contribution.

THE INVERTEBRATES

Our knowledge of the invertebrate animals of woodland soils is very meagre. Most of the investigations on soil invertebrates are restricted to crop soils and grasslands (meadows). Similarly we are much better acquainted with the fauna of the litter of woodlands than of the underlying mineral soil. Bornebusch's report (7) still remains the outstanding contribution on the fauna of forest soils.

The effect of higher insects

Of the various groups of invertebrates the higher insects form a natural, homogenous group. These animals spend a part of their lives above the soil and litter, using the latter for hibernation, aestivation, oviposition, and as a medium or shelter for the immature stages. The latter are frequently so different from the adult form as to constitute a special field of study. Since the higher insects are able to fly they are highly motile and therefore usually thinly sprinkled—especially the larger species.

Psocids

"Book-lice," especially of the subfamily Caecilinae, are fairly common in litter (usually only the wingless forms are obtained from drying funnels) but do not materially affect the soil (23, 4).

Hemiptera

Weese (98) and Blake (6) found that during the later autumn certain leafhoppers (Cicadellidae) and lace-wings (Tingidae) migrated from the forest border into the forest to hibernate in the soil. They give no indication of the numbers of the various species per unit area! Mealy bugs are common soil insects in some localities (67).

Cicadas are woodland insects which spend most of their immature life in the soil. Their migration down into the soil and search for a rootlet to suck on is affected when still very small (a few days after hatching). The immature stages, whether extending over a few months or seventeen years, are spent in an earthen cell six to twelve inches below the surface. In late autumn they migrate downward to a depth of two feet (latitude of Washington, D. C.) to hibernate, returning to the six- to twelve-inch stratum in the spring. They may be so abundant that the individuals are two to four or five inches apart—all within the same general soil layer. Marlatt (71) records nine per square foot in a dense oak forest of Washington, D. C. When ready to emerge, the exit holes (averaging $\frac{5}{16}$ of an inch in diameter) are formed some time before emergence actually takes place. Thus the annual or biennial species are more important as soil channelers than the thirteen- and seventeen-year species.

At least nineteen genera of aphids are subterranean, feeding on plant roots. Although some species pass part of their life cycle on other hosts above ground, some of them pass their entire life cycle in the soil. Some species are restricted to certain host plants while others enjoy a varied diet. The food is sought by wandering about through the soil (30). Many species, however, depend upon ants to carry them to their food while in the egg stage. In the case of the corn-root aphis (*Aphis maidiradicis*) the eggs are stored below frost line by the ants and

placed on the roots of the host plant in the spring (33). Soil aphids are to be found on roots of forest trees as well as on roots of grasses and cultivated plants. Roots of the following plants are recorded as hosts: grasses, Polygonaceae, legumes, Rosaceae, various herbs, *Barbarea*, *Alnus*, *Abies* (58, pp. 448), Composites (33). They occur to a depth of at least two feet. Since they are of general occurrence, and stimulate ants to do a good deal of soil channeling in order to insure an adequate supply of food on which to maintain their honey-dew cows, their effect in soil channeling is noteworthy. (Their effect on forest regeneration, through seedling mortality is also noteworthy.)

Thysanoptera

Although *thrips* are to be found in litter which is not wet, even to the extent of 200 per bushel, or a dozen per square foot of surface, they are not known to affect soil structure (95a, p. 44).

Orthoptera

Of the various families of Orthoptera, the Acridids (grasshoppers), Locustids (katydids), and Gryllids (crickets) affect the soil to the extent of drilling the surface to lay their eggs. This drilling varies in depth with the size of the insect, length of ovipositor, and extent to which the abdomen is worked into the soil. It varies in intensity with population density. Population density varies with soil type. Sandy soils, dry soils, exposed (thinly vegetated) soils support dense populations of Acridids; moist soils with dense herbaceous covering (meadows) support a fairly dense orthopteran population. Woodlands especially dense, moist woodlands, harbor but few grasshoppers though they are common along dry woodland edges and openings.

Typical woodland species of southern New England are: *Chloealtis conspersa*, which lays its eggs in dry sticks and logs; *Spharagemon saxatile*, on high wooded ledges; *S. bolli*, in open woods; *Melanopus punctulatus*, among pines (oviposits in the thick bark or crevices of the trees); katydids and camel-crickets, about logs and stone piles; ground crickets (*Nemobius carolinus*), in open woods; *N. maculatus*, in low open woods about logs (95). (Tree-crickets do not oviposit in the soil.) Thus woodland grasshoppers occupy special niches in the forest and have various habits of oviposition. Mole crickets burrow about in the soil much like moles, but in New England are confined to such sites as stream and pond margins. Some mole crickets in other regions burrow about in dry soil.

In favorable situations and conditions, one of the commonest medium-sized species of grasshoppers will inter 125,000 egg masses per acre. These require a hole one inch deep by three-sixteenths in diameter (62). Oviposition occurs once or twice annually, preferably in undisturbed fairly compact soil. Different species oviposit at different times through the spring and summer. Dry fields and meadows may harbor as many as six to ten species of grasshoppers; heavy moist woodlands, none.

Thus the effect of the Orthoptera in drilling the soil surface may be locally intense to negligible. The effect of katydids and camel or other crickets in woodland soils is usually not notable though it might become locally intense, especially in areas and countries where woodland species occur to any extent.

Lepidoptera

Many caterpillars pupate in the soil, different species to different depths, even to ten inches. Conversely certain Sesiidae tunnel four to seven inches up through the

soil from the tree roots, in which they have been burrowing, to the soil surface to pupate (54). Although the hawk-moths make the largest burrows (three-eights inches or more in diameter) they do not usually occur in great numbers. The canker worms (*Paleacrita*) burrow into the soil to a depth of from two to five inches to pupate. The Citheroniidae (Ceratocampidae) pupate in the soil to hibernate. Some species are single brooded (*Anisota virginiensis*), others have two broods per year (*A. rubicunda* and *A. stigma*). Most of them feed on forest trees including persimmon, gum, cedar, cherry, and sassafras. *Anisota senatoria* pupates three to four inches below the surface of the ground to over-winter. It occurs in abundance only over small areas at any one time. The green maple worm (*Xylina antennata*) has similar habits (61, 47). When at times any of these species cause serious defoliation of trees, the numbers entering the soil would considerably affect soil structure.

Since many of the lepidopterous larvae are over an eighth inch in diameter, their effect in soil channeling is of note where they occur to any extent. I fail to find data on their relative numbers in forest soils. Such figures would vary from month to month since different species pupate during different months. In Danish forest soils (7) larvae were only occasionally found (they very quickly pupate) while pupae would tend to remain undiscovered on the drying funnels. To obtain such numerical data, square meter soil samples would have to be taken through the year and to a depth of three feet, and the soil sieved.

Since several hundred species pupate in woodland soils in the northeastern states (teste Forbes) the effect of Lepidoptera on soil structure is noteworthy. Very locally, sporadically, and occasionally, it becomes intense. Their collective and cumulative effect is considerable and may be controlled in part by encouraging the growth of the food plant of each digging species.

Hymenoptera

Certain sawflies burrow into the ground to pupate. The ash sawfly (*Tomostethus multicinctus*) pupates in an earthen cell about half an inch in the soil. The elm leaf-miner (*Kaliofenusa ulmi*) enters the soil to a depth of about an inch to pupate (61). The larvae of the blackberry leaf-miner (*Scolioneura*) burrow six to eight inches into the soil to overwinter and pupate (31).

Some Calcids and Cynipids enter the earth to pupate. Some Cynipids (*Belonocnema*) form root galls in sandy places (Florida and Texas) (99). They are, however, extremely local.

Most of the digger wasps of the families Pompilidae, Sphecidae, Larridae, Bembecidae, Philanthidae, Crabronidae and some of the solitary wasps (Eumenidae) dig burrows (either simple or variously branching) in the earth to lay their eggs—usually in sandy or sunny (dry) places (27). *Sphecius speciosus* (an inch and a quarter in length) digs burrows two feet or more in depth (27). The digger wasp *Ammobia ichneumonea* (L) digs a nest tunnel 5–7 inches long, to a circular chamber 1 inch in diameter, from which radiate 2–6 tunnels 1–2 inches long, ending in oval cells 1½–2 inches long and ¾ inch wide. These are stored with 2–6 grasshoppers (50).

The Scoliids (*Tiphia* and *Elis*) burrow about through the soil in search of their host the June beetle larvae and related genera (34).

Some of the social wasps (Vespidae) build their nests in hollows which they excavate in the soil. As the colonies

exist for only one season—each overwintering female starting a new colony in the spring—they are one of the most active soil movers among the insects. I well remember how frequently my ankles burned while tramping about through an old growth stand of long leaf pines in the Piedmont of South Carolina, and how frequently I was prevented from taking a litter sample at chosen points by these soil inhabiting yellow-jackets. *Vespula* may build their large (10 inches x $6\frac{3}{4}$ inches) nests in hollows in clay banks or in the forest floor nine inches below the surface. These nests have a burrow running back from the nest for as much as one hundred and fifty-nine inches and to one inch in diameter (69). Some of the species of the solitary wasp *Cerceris*, which is colonial, dig a tortuous burrow to twenty-four inches long and to seventeen inches deep, with galleries one and a quarter inches long for the larvae. The burrows are from half to three-quarters of an inch in diameter. Thus an area inhabitated by such a colony would be pretty well riddled with fairly large burrows. Fortunately, the colonies are limited in number (81).

Many of the solitary bees (Apoids) make their nests in mineral soil. They are difficult to find because the entrance is hidden—as by the leaf of a rosette plant. Some Andrenids excavate more or less branched tunnels, each branch stocked with a single egg (and food). The main shaft of the one nest of the larger Andrenas (the size of a honey-bee) exceed a foot in depth. As some of these bees are colonial, a square rod of ground may include several thousand such nests (27).

Species of *Halictus* burrow in sides of clay cliffs and sand banks. Several females cooperate in sinking the main shaft, from which they individually dig out their several galleries, thus forming "cities composed of apartment houses" (27). Some Megachiles dig simple burrows in the soil in which they build egg or brood cells end to end.

In general, wasps and bees are not common in moist woodlands, preferring dry, sunny woodlands and open places. Colonies are commonly found in bare places with good drainage. Thus their annual contribution to soil structure in mesophitic woodlands is rather meager.

Of all the Hymenoptera, perhaps of all the insects, the ants are by far the most important soil movers. Even if, like all Hymenoptera, they are not abundant in moist woodlands, they are as important in dry woodlands and in grasslands as are earthworms in moist woodlands. In a weedy abandoned field in northern New York, I have seen a colony on nearly every square yard, spreading the yellowish soil in discs as large as a stove lid over the black surface soil. Although they spread a great deal of mineral soil over the organic litter, they do not draw an appreciable amount of organic litter into their galleries. Even those species which store their nests with plant seeds, clean off the pappus, and abandon the thin unfertilized seeds brought in by some workers, where they accumulate outside the nest as a midden heap at the entrance. The commonest woodland ants in the mesophytic woodlands of the east are *Ponera coarctata pennsylvanica* and *Myremcina graminicola brevispinosa*. These primitive species form small colonies but occur in every square yard of the woodlands. There are several other ants nesting in our mesophytic woodlands but all of them nest under stones and in humus (101), so that the amount of soil they move is negligible. Although the large carpenter ant (*Camponotus pennsylvanicus*) is common in woodlands it does not enter the mineral soil. Although the mound-building ant (*For-*

mica exsectoides) forms conspicuous mounds two to five feet across, thereby moving a large amount of soil, it is found only in glades and open places; its effect is therefore very local.

The only study on quantitative distribution of ants was carried out on the steppe formation (75). In the tchernozem soils, one square kilometer contained an average of 415,000 nests; alkali soil, 340,000 nests; saline soil, 257,000 nests. Factors influencing the distribution of the ants were composition and density of the vegetation, soil moisture, exposure, presence of other animals. The lowest and most wet areas were entirely devoid of ant nests!

Thus ants are as unimportant a factor in soil structure in mesophytic woodlands as they are an important factor outside of such moist shelter.

Diptera

Flies affect the soil in oviposition, as a retreat for pupation, and as the medium of the immature stages of certain families. Their effect varies with the size, extent of burrow, and local abundance of the species (29).

Some Tipulid larvae live in decaying wood, in soil of all types, eating roots, earthworms and other soft-bodied animals (3). Although they occur in nearly every square foot of litter, their presence in the soil is conditioned by the depth of the humus layer. In Denmark Tipulid larvae were found in the soil only occasionally (that is, one in every seven square-foot samples: maximum number in one sample, nine) (7).

Some Cecidomyid larvae live in decaying organic matter, many pupate in the soil, others live in roots forming galls, still others are predators on mites and insects. In Denmark they were found only in soils of resinous woodlands and to a maximum of twenty-one in one square foot (7).

Many Chironomid and Sciarid larvae live in moist organic soils and decaying organic matter. They are scavengers. Sciarid larvae are common in spruce litter.

Some Mycetophylid larvae live in rich soil, in decaying wood, in decaying vegetation and such plant parts as rotting grains, green bulbs, potatoes, and roots. In Denmark (7) they were obtained in large numbers in July and November (maximum in a square-foot sample, 125). *Phaenocladius* is one of the common soil genera, especially under pine, for the larvae eat out decaying pine twigs.

Psychodid larvae live in decaying organic matter and dung. Bornebusch (7) recovered them only in the soil of a beech duff during March and November (maximum in a square-foot sample, 17).

Leptid larvae are common in most forest soils. In Denmark (7) they were found on an average of four or five per square foot, not infrequently thirteen or fourteen.

Anthomyid larvae are common in soils of deciduous forest although very irregularly distributed. In Denmark their numbers ranged from none to one hundred and sixty-six per square foot.

Thereviid larvae live in earth, certain species forming side channels to earthworm burrows. Some are saprophagous, others are predaceous on insect larvae.

Some Bibionid, Mydaid, Coenomyid, Asilid, Tabanid, Dolichopodid, and Bombyliid larvae are predaceous in rich soils (29). Certain Bibionid larvae live in decaying vegetation and grass roots, others hibernate in the soil (7). Asilid larvae burrow about in upland soils, Tabanids in low and marshy ground where they seek their prey, June beetle larvae and related genera. Some Dexid, Tachinid, and Bombyliid larvae search through sandy and porous soils after other species

of June beetle and related larvae. In Denmark Dolichopodids were found in soils under beech and pine to a maximum of twelve to a square foot.

Trypetids, such as the walnut husk-maggot (*Rhagoletis suavis*), pupate from half an inch to several inches in the soil (19). Certain Tachinids pupate in the soil to a depth of one inch, especially about the base of trees (28). Some Agromyzids pupate two to three inches in the soil (64). Such Sarcophagids as *Chrysomya macellaria* pupate from one to four inches in the ground (5).

The genera *Forcipomya* (Ceratopogonid), *Fannia* (Muscid), and *Lonchoptera* (Lonchopterid), were recovered by Bornebusch in one or two stands only, and in very small numbers.

No square foot of forest litter or soil is without fly larvae, so that their influence on soil structure is noteworthy. Although their cummulative and collective effect is important, their control is problematical.

Coleoptera

Beetles affect soil by burrowing into it to lay eggs, to pupate, to form retreats (for hibernation), and to feed on plant roots.

Tiger-beetle larvae form definite burrows in the soil, some species using a definite and characteristic soil type. The burrows may be perpendicular to the surface, spiral, slanting or otherwise, and as much as thirty-nine inches and even seventy-two inches deep, depending on the species and the latitude. The burrows of many species are over a foot in depth. The larva occupies its burrow for ten months to twenty-one months, unless found unsuited when it seeks better soil conditions to make a new burrow. Some species are colonial, others solitary. Mesophytic woodlands are avoided, most species preferring sunny, bare areas, often openings between plants. *Cicindela sexguttata* will burrow under fallen trees and in partly cleared places and glades. *C. scutellaris lecontei* was found in greatest abundance where oaks begin to displace the pines—near Chicago (55).

The large Carabids of the genus *Calosoma* lay their eggs singly or in groups of two or three, at least four to six inches in the soil. The larvae pupate eight to ten inches deep in soft soil, or less in compacted soil. Their numbers may reach twelve per square yard when caterpillars are abundant (21). Carabids of the genus *Clivina* migrate through the soil from near the surface to as much as two feet, as the surface soil becomes too dry (80). Bornebusch records an average of less than one adult or larva per square foot in mull soils, with a maximum of three or four (7).

Elaterid larvae burrow about in the soil. Some live in the soil for as much as three years before pupating (65). During the winter the larvae descend to from four to six feet for hibernation (53). Although nearly every square foot of forest litter harbors Elaterid larvae, their abundance in the mineral soil varies locally. Different species are partial to different soil types (degree of compactness and moisture) (52). Bornebusch records an average of about eighteen *Althous* larvae per square foot in raw humus, with a maximum of fifty-one, but only an average of two per square foot in mull soil (7). They eat plant seeds, roots, and decaying wood.

The Heteroceridae live in burrows which they excavate in sand or mud at the margins of bodies of water (27).

Certain Staphylinid larvae live in the soil (94). The large golden Staphylinid, *Creophilus villosus*, lays its eggs in the soil where it spends its thirty-seven days of

predaceous larva-hood before pupating in an earthen cell (1). Although nearly every square foot of forest litter contains Staphylinids, their occurrence in the soil varies with the depth of the humus layer. Bornebusch records an average of two larvae and two adults per square foot of mull soil, with as many as twenty-five in raw humus.

Certain Chrysomelids (*Galerucella*, *Lema*) pupate in the soil (43). The linden-leaf beetle (*Calligrapha scalaris*) enters the ground to pupate and later reënters as an adult to hibernate (102). Various flea-beetles pupate in the soil to three inches deep (24, 70, 87). Some flea-beetle larvae are root eaters.

The Scarabaeids include many species, the larvae of which live in the soil. Some feed on roots, some on decaying wood, and others on dung buried by the parents (27). June beetles (*Lachnosterum*, *Phyllophaga*) spend three years burrowing about in the soil (46). Of the many species, some are woodland, feeding on the rootlets of seedling trees. The eggs are deposited from one to eight inches below the surface in balls of earth formed by sticking particles of soil together. In the autumn the young grubs burrow downward to pass the winter. "In the spring they move upward, eat ravenously, do their greatest damage this second summer, and, migrating downward in the autumn, spend a second winter deeper in the soil. In the second spring they return toward the surface, feed for a time, and transform to pupae in earthen cells in June" (61). As there are three broods, the three stages occur in the soil each year. June beetle larvae are characteristic of cultivated sites where they may occur to the extent of ten or eleven per square foot; woodlands, however, harbor related species. *Cyclocephala villosa* larvae spend about 350 days in the soil; *Anomala binotata*, 85 days (59).

Larvae of Japanese beetles live a few inches below the surface, burrowing about in search of food. The maximum number is 46 per square foot (in grassland). Females burrow into the soil 2–4 inches to deposit their eggs every day or two for a period of 30–45 days (44). Geotrupes excavates a dung pit for each egg. Woodland species have corresponding habits.

Bornebusch records less than one Cantharid larva per square foot of mull soil with a maximum of twelve. They show a preference for mild deciduous woodlands.

Adult Ptiliids (Trichopterygids) occurred in beech mull soil of Denmark (7) on an average of one per square foot (maximum is twelve) but were much more abundant in oak mull soil.

Some of the larvae of the large Prioninae feed upon roots of woodland trees (27).

The hickory nut weevil (*Balaninus caryae*) enters the soil to a depth of six to eight inches to pass the winter. The five species of *Balaninus* attacking the different species of acorns have similar habits. The hickory nut and butternut curculios (*Conotrachelus affinis* and *aratus*) also pupate in the soil from half to three inches in depth (20). Other curculios (*Polydrusus*, *Phyllobius*, *Otiorhynchus*) pass the larval stage in the soil feeding on tree and plant roots (78). Bornebusch records curculios chiefly in oak mull, sometimes as many as five per square foot (7).

Weese (98) and Blake (6) found that during later autumn certain beetles of various families migrated from the forest border and from surrounding fields into the forest to hibernate in the soil—some less than 10 cm. (four inches), some more than 10 cm. deep. They give no indication of the numbers of the various species per unit area!

Thus beetles are one of the most important orders of insects in channeling the soil, especially in open places and in relatively dry soils.

Higher Insects—General Summary

The foregoing review though comprised of odds and ends of examples indicates two fundamental phenomena: (1) that the higher insects use woodland soils as places of shelter, hibernating in the soil during the winter, (2) that a large percent of the higher insects prefer dry, sandy, sunny (warm) soils for nesting sites. Unfortunately most of our knowledge of soil insects has been restricted to agricultural land. We do know, however, that certain families and genera of the higher insects are common in moist forest soils. Leptids, Staphylinids, *Althous* (Elaterid), Anthomyids in nonresinous, Ceccidomyids in resinous woodlands are the outstanding groups in soils of mesophytic woodlands. It should further be recalled that most of these insects spend only a part of their lives in the mineral soil and are, therefore, not geobionts but geophiles (67).

Though some of the higher insects annually enter forest soils for hibernation as adults, we are ignorant of the extent (number of species) or intensity (number of individuals per unit area of surface) of this periodic type of soil channeling. Finally, the literature on the higher insects which inhabit the soils of the woodlands of the northeastern states is not only very scattered but extremely fragmentary.

The primitive insects (Microarthropods)

The species grouped under this head are minute and wingless, and transform from larvae to adult by very gradual stages. Most of them are poorly sclerotized, lack organs of defense and offense, and are not highly colored (with the exception of some of the springtails). They are the commonest insects of the mineral soil, ceaselessly threading its many channels, thereby helping to keep them open. They are either saprophagous, coprophagous or suckers. These insects freeze up during the cold weather and thaw out when warm, thus being active whenever their medium is above freezing. Since they are apterous they must be close enough to each other to meet and mate within their short adulthood. Thus they are to be counted y the dozens or hundreds per square foot while each species of the higher insects are usually represented by less than half a dozen individuals per square foot or by one or two per square yard. The ratio of immature to adult is very high, signifying a great mortality. They are therefore a very important source of food to the small predators. The largest group is the:

Collembola

Springtails abound in all moist or fairly moist soils to unknown depths. Volz (93) analyzed square decimeter (2 cm. deep) samples from woodland soils near Leipzig, taken at depths of over 10 cm. (15–17 and even 35 cm.). He found *Folsomia quadrioculata* in half the samples, often one specimen but up to seven. It is much more abundant in the upper layers and in the litter, but was absent in some of the spruce woodland samples, though common throughout the year. It is common in most habitats in Greenland (57) and is one of the commonest humus species in the White Mountain region. *Onychiurus armatus* occurred in half the samples, two or three (maximum six) per sample, though more common at less depth. *Onychiurus ambulans* was found in only two out of sixteen samples below fifteen centimeters. *Tullbergia krausbaueri*

occurred in half the samples (especially in spring and summer) to the number of four or five per sample. *Isotoma minor*, probably a holarctic species, was twice found between fifteen and thirty centimeters in June. *Friesea mirabilis*, *Isotoma notabilis*, *Achorutes* (*Hypogastrura*) *armatus*, and a Zenyllodes were not found otherwise. Corresponding and closely related species occur in our own region. Volz's thirteen lots average five individuals per cubic inches taken from six to thirteen inches deep. This small number of samples showed no population decrease with depth. Jacot (67) found 144 springtails in a square foot sample of an 80-year-old old-field woodland, between one to four inches deep, 28 in the next three inches and 16 between 11 and 13 inches deep in the Appalachians. The smallest sample with the eight specimens was from a grass bald. *Proisotoma sepulcralis* (Folsom) occurs in great abundance on cadavers buried six feet deep (45). Thus it may be concluded that the mineral soil harbors a varied fauna of springtails probably to the depth of root penetration (8–15 feet or more). The number would be conditioned by the number of dead roots and rootlets, or dead animals (cadavers, mice, earthworms) occurring in the soil from place to place, the depth of the water table, and the incidence of dry spells.

Proturans

Yellow-tips occur as far north as the White Mountains. They may be encountered in the mineral soil in the south under thin litter or mull soil conditions. They have sucking mouth parts, but no one seems yet to have discovered their food. Jacot (67) obtained two specimens from ninety cubic inches of soil 11–13 inches deep under Andropogon sod of a bald, as well as an occasional individual 4–7 and 11–13 inches deep under woodland in the southern Appalachians. Their effect is similar to that of the Collembolans though not so intensive.

Campodeoidea

Japyx is not uncommon in mull soils of the southern states. Though more robust than Proturans it is so much less common as to have but negligible effect on the soil.

The Acarina (*Microarthropods*)

Mites are the most ubiquitous and numerous soil arthropods. Although minute, they make up in numbers what they lack in size. Most of them are saprophagous though many are predaceous and suctorial. Certain species are structurally modified to dig, much resembling moles in body-form and in development of anterior legs. Most (if not all) of the soil diggers have the anterior tarsi furnished with a stout curved spine which may be used as a pick.

In addition to the diggers, many of the litter species enter the mineral soil to oviposit. Other species eat out dead roots and rootlets, thus secondarily channeling the soil. They undoubtedly go as deep as plant rootlets (eight to fifteen or more feeet), provided they do not encounter the water table. Although at least one species, found at a depth of thirteen inches in two localities, has never been found outside the mineral soil, most of the species enter the organic layers on occasion.

They are so numerous that most investigators have not endeavored to identify them or even to count them accurately. Jacot (67) has given specific data on a few trial samples from the southern Appalachians. He found 1008 saprophytic and suctorial mites in a square foot sample from an eighty-year-old old-field woodland, between eleven and thirteen inches.

There is no other specific data on the Acarina of the mineral soil of woodlands.

In brief, although this group comprises minute species, they are so generally distributed throughout the mineral soil and so well provided for digging and channeling the soil, that they are the most important group of soil microarthropods.

The Chelonethida (Microarthropods)

Pseudoscorpions are small, active suctorial predators, living mostly on Collembola. Chiefly a litter or subcortical group, they may hibernate in the soil. *Microbisium parvulum* is common in most forest soils, though mull soil harbors much larger numbers.

The Araneida

Spiders, especially minute species, although common in the litter, are not known to enter the mineral soil of woodlands to any extent. The few Lycosids which have developed the burrowing habit are too widely scattered on the forest floor to exert any notable effect. The drier soils, especially unwooded, harbor a more extensive population of fossorial spiders, which climax in the trap-door spiders.

All spiders are predaceous, with sucking mouth parts.

The Diplopoda

Millipedes are predominantly a soil and litter group. They are intensive soil channelers.

"Since moisture is the most important factor limiting the distribution of millipedes, moist, dense woodlands with much undergrowth are their optimum habitat. Here they are sheltered from the sun, they are provided with a copious supply of decaying vegetation for food, and they are provided with many retreats in which to transform (moult) and lay their eggs. In open woods with organically impoverished soils the millipede fauna is correspondingly reduced. Moreover woodlands strewn with stones and boulders shelter a more extensive millipede fauna than woodlands of alluvial or flood plains. [It is easier to obtain millipedes by turning over stones (a convenient diurnal retreat) than to dig them out of their earthy retreats; for on the whole, they prefer sandy to the more compact soils.] The woodlands which are most favorable to millipedes have a definite stratum of underbrush or herbaceous plants, decaying tree trunks, branches and bark, thick moss mats, a deep leaf layer which gradually merges into pure humus. On all these decaying plant parts develop many large and small moulds and mushrooms which are browsed upon especially by the Ascospermophora. Altitude limits distribution only as humidity, decaying vegetation and shelter decrease" (92, p. 15).

Certain species are quite local and form colonies in the most favorable situations; other species are fairly evenly distributed throughout their habitat. Romell (83) describes the influence of such a colony (*Fontaria*) on soil structure, and figures their excrement clumps. Bornebusch (7) found Julids strongly associated with mull soils, while Polydesmids seemed independent of soil types. Diem (35, p. 159) found species usually recorded as from under bark and stones, in the upper and middle soil layers especially when rich in humus. Soils poor in humus are inhabited by only certain species. It is evident that millipedes normally live in the soil but that on certain occasions they emerge and crawl about the litter, hiding under stones and bark at daylight. Diem found that the type of soil determined the specific population. He records three definite soil types: dry, shallow soil with slight humus content; damp, deep soil; damp to wet, mild humus of irrigated meadow. In a sample of alkaline soil (10 x 10 x 5 inches) from mixed woods he obtained 33 millipedes representing six species, while in a spruce wood sample he secured 60 specimens of two species. These were his richest woodland samples which show violent fluctuations in number of individuals and of species. Bornebusch obtained an average of six Julids

per sample of 1183 cubic inches of mull (maximum 12 and 13) and but one Polydesmid (maximum 4 and 5).

Many species are sensitive to agricultural and anthropic disturbances. Increasing dryness and cold induce them to go deeper into the soil. Some Julids are much more resistant to dryness than are most of the Polydesmids. Certain species prefer alkaline to acid soils. They are able to withstand immersion in water from half an hour to several hours—depending on the species and the amount of air in the water.

The eggs of some of the litter species are laid in the soil, enclosed in fecal matter. Evans (41) found that some species lay all their eggs in one nest while others lay a few eggs in each of several places. Some millipedes make their nests in concavities in the litter (as acorn cups), while others dig into the soil until they find a firm foundation, as a stone. Morse (74) records *Fontaria indianae* ovipositing in sand to two inches deep.

The food of Julids is predominently decaying roots, wood, leaves, and faeces; certain species prefer fungi; some polydesmids will eat well-decayed animal matter. Many species injest soil and mineral particles with their food, and this forms part of their faeces. Certain species of millipedes may feed on crop plants when the amount of organic matter and humus in the soil is depleted to the extent that the animals would exert more energy finding the humus than they can derive from it (9). A few genera have piercing suctorial mouthparts.

Since nearly all recorded observations on east American millipedes were made on surface animals, practically nothing is known of the habits of truly soil millipedes: in fact, I am unable to determine which are typical soil species and which are predominantly litter species. One of the characteristics of the rather large Fontarias is their habit of migrating from one locality to another, often by the million (18). Brade-Birks (8) records similar migrations after a heavy rain following a drought.

To summarize: although the habits of millipedes, especially soil species, are but little known, these arthropods stand out as one of the important groups of soil animals, affecting soil structure by their burrowing habits. Though one species of the northeastern states is as large as a lead pencil the most generally distributed and most abundant are minute.

The Chilopoda

Centipedes are very active and much less local than millipedes. As they are carnivorous and predaceous, they wander more widely in quest of food than do the millipedes. Diem (35, p. 160) records Geophilidae mostly from depths of eight to sixteen inches. In general, he found (p. 161) Chilopods more frequently, to a certain depth, than other groups of soil animals (the mites and other minute forms not studied). It is difficult to obtain data on their distribution in the soil because of their speed and of the large number of immatures ("undeterminable"). Taking large samples should overcome these difficulties. Bornebusch found Lithobiids more abundant in mull soil, while Geophilids were common everywhere though more especially in raw humus, and very irregularly distributed; one of his samples ($\frac{1}{10}$ of a square meter—about a square foot) yielding fifty-two individuals. In a sample (10 x 10 x 5 inches) from mixed woods with alkaline soil, Diem obtained twenty-seven individuals, representing five species, while in a spruce sample from twice that depth he collected twenty of the minute *Scolopenrella notacantha*. These were his richest

woodland samples which show violent fluctuations in number of individuals and of species.

The Isopoda

Sowbugs (pillbugs) may occur locally in forest litter and possibly in the mineral soil. Bornebusch records them as common in oak mull at one locality only (out of 80 samples, 11 localities). They descend to hibernate, and probably to aestivate and escape drought generally.

The Mollusca

Land-snails (land-shells) are found in all woods which have not been heavily grazed, trampled, or burned. The majority of the species are minute (a few millimeters) though a common species has a shell nearly an inch in diameter. Some species are quite drought resistant. Populations cannot be sampled with the same technique as is used for the arthropods. Some ascend vegetation to feed on green tissues, some are found on dead wood, but most of them are found in or on the litter entering the soil to aestivate and hibernate and many to oviposit. Jacot (66) found five species in most old-field woodlands, including white pine plantations in the southern Appalachians. The number of individuals per square foot varied considerably (maximum : 28). Presumably at least that number enter the soil in the autumn. The number of species and individuals in mull (cove) litter was much greater. Bornebusch (7, p. 86) found four species (30–70 individuals per square meter) common in most deciduous litters. Alkaline regions support a much more abundant and varied molluscan population. Diem (35, p. 35) secured the greatest number of species (eleven) and specimens (seventy-four in a ten-inch-square sample) from a mixed wood with strongly alkaline humus soil. Little disturbed mesophytic woodlands should yield at least a dozen species; old-field woodlands, four or five. The number of individuals varies considerably locally, depending on degree of shelter. There is very little detailed quantitative data in this field.

Thus the effect of mollusca in soil channeling is seasonal and varies considerably with site conditions—which limit the population.

The larger Oligochaeta

Earthworms are undisputedly the most important animals affecting soil structure and soil fertility in woodlands. They not only push mineral soil out over the organic horizons but draw down into the mineral soil a certain quantity of organic matter, thus acting as mixers in two ways. Worm castings are frequently so mixed with organic matter that they constitute a high grade soil for plants to grow in (82). Their channeling of the soil locally is exceeded by no other animals, for *Lumbricus terrestris* reaches depths of six to eight feet for hibernation and during droughts, and they occur to a density of ninety per square meter in woodlands (10–15). Wollmy (104) showed that earthworms greatly increase the pore volume in the soil, and thereby make it much easier for water to enter. It is chiefly in late autumn that they draw dead leaves into their burrows to line their nests, and for food. The leaf blades are softened by their emitted pancreatic secretion, and the petioles ejected as a midden pile about the mouth of their burrows. One is seldom aware of their presence as they are active above the surface at night and when it is damp and rainy (35, p. 153). They injest earth for its contained humus and organic content. The amount of their castings is therefore in inverse proportion to the amount of

leaves injested. When thus feeding on the soil humus their burrowing activities are more or less continuous. The humus is also used to line their burrows. They function as planters of maple trees by drawing maple keys into their burrows to feed on the key wings (86). Diem (35, p. 152), working in the Swiss mountains, found earthworms almost exclusively in the upper three inches of soil and working horizontally. Large numbers are often found dead on the soil surface after heavy rains. This phenomenon is explained by Merker (72, 73) as follows:

> "Rainwater may lose its oxygen content in a few hours in the soil. The air of the burrows and other crevices of the soil is, therefore, replaced after a heavy fall of rain by deoxygenated water, and a zone of air-hunger for the inhabitants of the soil will be produced. The worms will evade this oxygen hunger by going deeper; if however, they cannot go further down, they will come to the surface, and will then wander about exposed to daylight. Daylight is intensely harmful to them because of the ultraviolet rays, so that, even in dull weather they will in two or three hours be paralyzed to such a degree that they can scarcely crawl" (86, p. 368).

Dry periods are passed in a state of suspended animation (anabiosis) deep in the soil. Hensen (60) found that half the humus lined burrows were used by plant roots to grow deeper. Diem (35, p. 153) found that the worms almost always avoid soil with a dry top layer, as also soils which are subject to great fluctuations in moisture content in the upper six inches. In fact he found that the soil condition below six inches does not affect the worms. It is the upper six inches which are critical. Neither slope nor exposure affect distribution provided the upper six inches of soil are otherwise favorable (35, p. 154). This does not apply to *Lumbricus terrestris*. Vegetation influences earthworms in so far as the amount of cover affects moisture conditions and its alkalinity.

In the northeastern states the indigenous earthworms are found chiefly south of the glaciated area. The earthworms of New England and New York are often species introduced from Europe. For example, the largest species is *Lumbricus terrestris* so carefully studied by Charles Darwin (32). The spread of this worm throughout our woodlands is not only slow but erratic, because it depends to such a large extent on artificial factors. The fisherman has done much to spread this worm along water courses by dumping his canfull at the end of the day and by throwing out small ones along his course. Farmers have aided by transplanting shrubs and plants from one farm to another, and by throwing garden thinnings across the road. Since the cocoons are deposited under the soil surface (and contain few embryos, often only one) (86, p. 662) they would not be transported on man's boots or cattle's hooves. Some undoubtedly have been transplanted in freshly dug bags of potatoes and other such products—especially on days of high atmospheric humidity. Suffice it to say that although this largest species is now found throughout New England and New York in favorable localities, it is very local. It becomes sexually mature in one year and lives five to six years (86).

A common European species (*Allolobophora longa*) lives from five to ten years, while the little European *Eisenia foetida* of manure and compost, and mouldering wood, lives three to four and a half years.

I have found what appears to be *Lumbricus terrestris* in fairly dense colonies under oak woods, northern hardwoods, and tulip-poplar coves in New England, and in smaller numbers under old-field spruce stands in alkaline soils, and at the edges of swamps under spruce and arborvitae over limestone. It is difficult to find poplar stands along streams without

this worm. It is intolerant of physiologically dry, highly acid soils with little or no humus. Calcium salts are necessary to replace the loss in the calciferous glands. These salts may be obtained from the deeper soil when overlain by an acid humus. A constantly high water table, or a water table high most of the year is unsuited to *L. terrestris*. Ground fires at night (when the worms are outside their burrows) would aid locally in their extermination. Orieux (77) states that they wander at the rate of 0.2 meters (their own length) per minute.

Some species of earthworms are typical litter dwellers or live under bark of old or dead trees and fallen branches (76). The effect of such species on the soil is much more limited than is that of the truly soil species. Bornebusch (7, p. 88 f.) found *Lumbricus rubellus* and *Allolobophora turgida* in beech woods; very few *L. terrestris*. He also found *Dendrobaena octoedra* in all raw humus soils and under a variety of conditions which excluded other species. Ribaucourt and Combault (82) relate how it lives in the moss on the rocks of high mountains and assiduously gathers the leaves carried by the wind, dragging them into their retreats to devour them, and forming mull in unpropitious localities. In Denmark (7, p. 95) it is of the utmost importance, being in most places the only species of earthworm living in raw humus soil. *Dendrobaena arborea* is also found active in forest soil (7, p. 94). *Eisenia rosea* is quite common in rich, clayey forest soil. In winter and the dry periods of summer, it may be found rolled up like a small pink ball at the lower boundary of the mould (7, p. 96). Bornebusch regards *Allolobophora turgida* as the most important (because the most abundant) species of earthworm in mull soils of Denmark, of sandy as well as of clayey texture. It lives in the mully topsoil, directly under the leaf layer, but never in it. *Allolobophora trapezoides* replaces it further south in Europe. *Allolobophora longa* closely resembles *Lumbricus terrestris* in appearance and habits. *Allolobophora chlorotica* is most commonly found in clayey soil in the forest. *Lumbricus rubellus* he regards as one of the most important species of Danish forests, being one of the most adaptive as to mully sites. It was found in great numbers in beech raw humus, and also occurred in oak scrub and in coniferous plantations on the heaths. Although *L. terrestris* is much more choosy of sites, its work is of far greater importance than *L. rubellus* because of its size and the depth of its burrows. Diem (35, p. 38) records *Eisenia rosea* and *Allolobophora aporata* from spruce soil on limestone and *Octolasium lacteum* from spruce with no lime.

In little Denmark there are nineteen species of earthworms, most of them found in woodlands but under different conditions of soil, humidity, and humus content. In favorable localities Bornebusch (7, p. 100) got 358 and 254 worms representing nine species from a square meter of soil (depth not stated). On page 103 he then lists the worms found in eight different types of woodland soil. Friend (49, p. 15) lists thirty-seven species of Lumbricidae from the British Isles. Olson (76) records twenty-two species from Ohio, ten of them common to Denmark. Four useful Danish species, including the very tolerant *Dendrobaena octoedra*, are not recorded from Ohio. This suggests the introduction into America of useful forest species not yet found here. Since the earthworm population of New England and New York is one of chance introduction—(1) postglacial southern species, (2) European—there is a splendid opportunity to greatly improve our forest soils by introducing desirable species in

any forest or woodland tract where the soil condition has deteriorated through abuse or careless management. Some species are peregrine, others are sedentary.

The smaller Oligochaeta

The pot-worms (Enchytraeidae) are minute whitish worms able to live under a much greater variety of conditions than the Lumbricidae (earthworms). Population density, number per unit area, varies from none to thousands per square meter. They abound in the upper three inches of soil, especially about plant roots, wherever the humidity is fairly constant. Dry soils, cold soils, or soils with great variations in humidity strongly limit the numbers. Alkaline soils, rich in humus, are the most favorable (35, p. 148). Certain species are, however, xerophile (16). Diem secured 5504 individuals in a square meter of soil under spruce on limestone. Bretscher (16) obtained 8000 per square meter in soil of pine woods (without herbaceous cover); they were chiefly in the needle litter. I have found an average of a dozen per square foot in the litter layer of spruce woods.

Their food consists chiefly of plant detritus along with a certain amount of mineral particles (35, p. 149). They divide the earth and humus more finely than do the larger worms (68). Some feed on nematodes by excretion of digestive enzymes. Thus they aggregate about nematode infested plants (below ground) (86, p. 646).

It is difficult to gauge the value of these minute worms, or their effect on soil fertility and soil channeling. Too little is at present known about their habits, and their numbers, and they seem too insignificant to have much influence. However, it must be remembered that they are much more tolerant than the Lumbricidae, and that they make up in numbers what they lack in size. We grossly underrate what does not loom large before our eyes. The Enchytraeidae should dominate the interest of several American investigators.

The Nematoda

The thread-worms are the smallest and most abundant of free-living soil worms. Since they have to be collected and studied by special methods they are very little studied unless they become of economic importance by attacking plants.

"Notwithstanding the enormous number of nematodes existing in every acre of arable soil, the actual volume and weight of the material composing the nematodes is relatively small. We cannot yet positively assert that they assist materially in the fertilization of the soil; it is, however, easily conceivable, in fact, there is a certain amount of evidence for the idea, that, indirectly, some species may be of considerable importance in maintaining or assisting to maintain a fertile condition."

"Though nematodes are small they are scattered through the soil in countless myriads in such a way that they must constitute an important mechanical factor. From the time they are hatched until death ensues, nematodes seem to be in constant motion. There is no evidence that they sleep. Such active organisms, existing as they do in every acre of arable soil in thousands of millions, must exert a more or less powerful mechanical influence" (26).

The nematode fauna of forest soils is almost unknown. Diem (35, p. 142) found them in the upper twelve to sixteen inches, in soils that were not too dry or that did not vary too intensely in humidity. Heavy, cold, damp clay soils and damp forest humus are not particularly favorable. Under all these conditions plant roots seem to be one of the most important factors.

RETROSPECT

The foregoing review yields the following generalizations:

1. There is an appalling dearth of knowledge both qualitative and quantita-

tive concerning the invertebrates which inhabit mesophytic woodland soils of the northeastern United States, or of forest soils in general. Our knowledge of the fauna of *forest* soils, especially quantitative, is more meager than is that of other culture types.

2. Much of our knowledge of soil animals is not specific enough to be of real value for culture or control purposes.

3. Animals may affect soil favorably (earthworms, millipedes, microarthropods) or unfavorably (social ungulates, social rodents).

4. Due to changes in culture types, especially plowing, much of our woodland does not harbor an adequate or balanced soil population.

5. Man may be unable to control volant animals, but the most important groups of soil animals are nonvolant (earthworms, millipedes, mites), have been severely localized, and are limited in dispersal by many man-made barriers.

6. Certain groups affect soil intensively; very locally, or intermittently (higher insects), while other groups exert a constant, general effect (earthworms, microarthropods).

7. Many insignificant forest animals, like woodchucks, voles, earthworms and mites are beneficial soil animals.

8. Many species of animals (mammals, burrowing birds, toads, insects) are important soil benefactors over a period of years, collectively and with cumulative effect.

9. Soil activity may be increased by encouraging ample growth of food plants of desirable soil-digging animals (especially such insects as Lepidoptera, root aphids). Certain insignificant trees and plants are important in initiating and maintaining good soil conditions through their effect in sweetening the upper layers (poplar, tulip tree, ash) and in intensive, ephemeral root penetration (annuals).

10. Forest management will yield highest results when a long time view-point especially of humble species, is entertained.

11. Burrowing animals dig winter burrows deeper with increasing latitude.

INTERRELATIONS

A square-foot sample of long undisturbed, unburned humus taken from an acre of spruce woodland of northern New Hampshire yields as many as two hundred species of arthropods, without including the one hundred to two hundred species of arthropods which are so thinly sprinkled as to be missed by the sole square-foot sample. All the animals of a square mile of long undisturbed, unburned forest floor thus total well over four hundred species, without including such widely spaced species as the deer, bear, red-shouldered hawk, and rattlesnake. Increase in area of sample increases number of species (without including new habitats) due to mobility, colonial nature, and rarity (localness) of certain species. The interrelations of such a complex are difficult to visualize, especially when we are ignorant of the food habits of many of the species. A detailed review of interrelations is therefore impossible at the present time. However, certain general aspects are pertinent.

THE STRUCTURE OF AN ANIMAL POPULATION

To understand the structure of a population of animals one must understand the structure of the plant formation encompassing it. All major anemophorus trees are life forms capable of thriving independently of other life forms. When living crown to crown to form a continuous canopy (either unispecific or pluri-specific) they form a forest *formation*

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(96, p. 139). The forest formation affords greater shelter and food supply to smaller species of plants and to animals than does any other formation (parkland, scrub, prairie, desert). The amount of shelter thus afforded is affected by intensity of wind action and of shade, and their concomittent factors (97, p. 268). The complexity of the forest formation is due to the size of the dominant life form—the tree. The kind or number of species of major (dominant) trees to a large extent determines the structure of the forest formation (96).

The minor structural units of the forest formation are the layers formed by the various plant forms represented, as: minor trees, shrubs, minor shrubs, herbs, mosses, lichens, algae, and organic debris (96, p. 330–331). Layers (strata) may be horizontal, vertical or oblique; plane, cylindrical or conic—depending on the form of the substratum.

The species of plants making up strata are of *sociological* importance only as they affect, or are affected by, other species of the formation. In such an agglomeration certain species are dependent on others or the effects produced by others, while some are independent, that is, capable of growing elsewhere, as in other formations (e.g. parkland, scrub, shrub desert, prairie, steppe). Species unable to live outside of the one formation or association are narrows (dependents); the others are wides (independents). To understand the structure of a formation *vital* relations should be determined. Much ecological work has been descriptive and quantitative, with little effort made to determine which species are dependents or independents.

Food Relations

All animals depend directly or indirectly on vegetation for nourishment and therefore existence. Hence animals do not form formations in the same sense as do the plants. They may be aggregated (for various reasons) to form populations or herds and colonies—unispecific or plurispecific. To postulate animal formations or associations in woodlands is a false concept. Similarly, a fauna is not a vital community, but a group of animals brought together by shelter, food, population pressures, migration and such historical factors as land bridges, winds, floods, fires. Each species in the fauna is not vitally connected with all the others. Many are "associates" by juxtaposition, proximity, common food. Some live just as well in another association or formation.

Animals dependent on primary foods (green plants) are *primary animals*—herbivores (phytophages). Saprophages are *low primaries*. Animals dependent upon primary animals are *secondary animals*, as predators and parasites, which may be tertiary, quarternary, etc. A hawk that feeds on snakes that feed on batrachians that feed on arthropods (of various feeding habits), is a quarternary or quinternary predator—better say a *remote predator* (remote from the primary supply). Fungivores, necrophages, and coprophages are *low secondaries*.

The various primary animals (phytophages) of a formation are often independent of each other. Each may depend on different plants or plant products of the formation. For example deer and rabbits are quite independent of each other, but both are present in the forest because of the advantages offered by the forest. They do not even compete, since the one is a high browser and the other a low browser. They are related to each other merely as *members* of the forest formation. Phytophagous animals are motile interstitials of vegetation, center-

ing about their nests (territory) or feeding grounds.

Primary animals feeding on the same food are *mess-mates*, sometimes *competitors*. For example, the elm-leaf beetle (*Galerucella xanthomelaena*), the elm sawfly (*Cimbex americana*), the elm sawfly miner (*Kaliofenusa ulmi*) (61), and the following caterpillars are all *associates* of the elm because they feed on the elm (in the same geographical region): *Nepticula apicialbella* mines upper side of leaves (Ohio), *Lithocolletis argentinotella* mines under side of leaves, *L. ulmella* mines upper side of leaves, *Coleophora limosipennela* eats the leaves, *Helice constrictella* feeds on the leaves, webbing the under surface, *Anchylopera fuscociliana* (leaf folder and eater), *Tetralopha asperatella* (leaf roller and eater), *Canarsia ulmiarrosorella* eats the leaves (forming a silk nest between the leaves) (47), and others. All these and many more are *members* of the elm tree association, and since they all feed on elm leaves at the same time of year, they are *potential* mess-mates, though seldom found on the same leaf at the same time, thus rarely *competitors*. The caterpillar, *Argyresthia undulatella*, feeds on the bast of the larger branches and trunk of the elm. It is thus an *associate* of the elm, and a *member* of the elm association but it has no vital (sociological) relation to the leaf feeders. Its relation to them is spacial—one of justaposition. On the forest floor many species of animals feed on faeces, many on dead leaves, and many on fungal mycelia. However, there often is a succession of species through degrees of reduction or decay (2, fig. 17, p. 154). Hence, mess-mates are a common phenomenon, but their mateship is sociologically fortuitious, often a result of historical or phylogenic factors.

To catch a lot of animals in a number of net sweeps or in a cylinder and classify them on the basis of numbers of individuals of each species as dominant and subdominants is a laboratory concept. Sweeping the foliage of an elm tree would give very different dominants and subdominants from tree to tree, from month to month, and from year to year without indicating interrelations—the structure of the population of the elm tree, much less the structure of an elm community. Thus to understand an association or a fauna, food habits are one of the most important interrelations (and one of primary economic importance to man).

Primary animals are to be found among all phylogenic categories of forest floor animals, but many of them also take in small amounts of secondary foods. In grouping animals by their food relations the major food is understood, for this will indicate the major effect of each species in the association. Even as small a category as a phylogenic family of animals will include primary and secondary feeders. For example, some ants (Myrmicidae) are graminivorous (*Pheidole* and *Tetramorium*), some fungivorous (*Atta*), and some are carnivorous (various) (100). Hence it is imperative to study the feeding habits of each in order to determine its sociological place in the community. This is just as true of Protozoa as of higher animals (85, p. 3, 3). Specificity is of considerable importance in evaluating a species. Many predators are wides (euryphagous) in their feeding habits, while many phytophages are restricted to one food (stenophagous or monophagous).

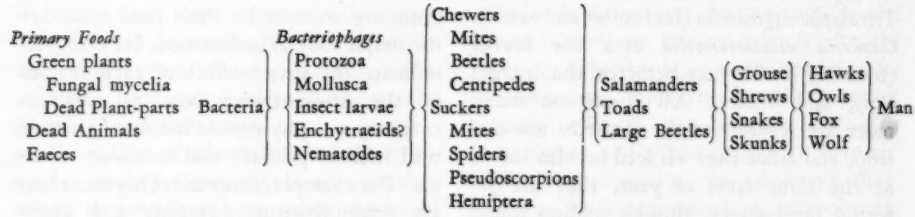
Food habits are conditioned by the size of the animal and its type of mouth parts, as well as by its internal conditions. The diagram on the following page should illustrate this point.

The following groups of saprophagous animals (with chewing mouth parts—a primitive condition) have developed

genera with sucking mouth parts: millipedes, springtails, Oribatid mites, Tyroglyphid mites (*Histiostoma*), Raphignathid mites, Nematodes. Thus there is a definite factor in animal tissues which, by causing attenuation of mouth parts, determines feeding habits.

Nesting Site

Nesting site is another important interrelation. This means the place where the eggs are laid. Place of hibernation, aestivation, pupation, moult, are not necessarily included. The nesting site is often the place where the immature feeds or where its food is brought. Hence food and nesting site may be closely related. The nesting and egg-laying habits of all species of an association should be known. In fact no animal can be properly evaluated as to its influence in an association until its entire life history, including its predators, parasites, diseases and competitors and their incidence, is known. This is a fundamental ecological principle. It is as true of Protozoa as of higher animals (85, pp. 2, 3).



In America the animals of an association are often ecologically classified on the basis of relative numbers—dominants, subdominants, etc. Recent work in ecology has shown that *numbers* of individuals of a primary animal is an index of available shelter and of available food (37–40). The relative numbers of each species gives a picture of the association at the moment of collection. Such numbers may fluctuate violently from year to year, or month to month, at times from hour to hour, depending on migrations, epidemics, hatching or transformation dates, and other factors. To set up an ecological classification based on numbers may be spectacular (a picture) but it is not vital. Should ecological studies comprise ephemeral pictographs or should they present vital relations? (It is much more difficult to analyze feeding habits and work out life cycles than to collect a net or can full of specimens and send them to specialists for determination. The former calls for a biologist, the second for a technician or clerk.)

Duration

The degree of dependance on the association (forest or layer) is expressed by the suffixes -bionts, -philes, -xenes. The soil and litter fauna (the geenton) is a practical unit, a layer of the forest, grassland or desert. It is one layer (one reel) of a complete picture. Its *geobionts* (67, p. 377; 48, p. 21) are directly dependent upon plant roots (or other underground parts), decaying plant parts, fungi, faeces, or other animals, for their *full* time maintenance and well-being. Those animals which spend *part* of their lives in the soil, either as egg or immature stages, or as adults, for hibernation, aestivation, oviposition, nidification, and feed outside, are *geophiles* (67, 48). Strays are *geoxenes*.

Collectively, they are *geocoles*. Geobionts able to live in the soil layer of another plant association (parkland, scrub, grassland) are *wides*. To classify each species of animal under such heads as food relations, effect on the associate or the habitat (trampler, dunger, borer, miner, chewer, sucker) and duration, tersely presents data on which can be based the place and the effect of that species in the association. The relative numbers of a species, under certain conditions, might indicate the intensity of its effect.

Daily Vertical Migrations

Volz (93) found that most of the pigmentless (eyeless) springtails of the soil occurred at the lower depths while the pigmented, patterned, fully-eyed species occurred chiefly in the litter. Collecting in spruce woodlands of the White Mountains (N. H.) in the early morning, when the ground was still in deep shadow and the litter still dew wet, I found that most of the pigmentless species were in the upper layers of spruce litter in great abundance while *some* of the pigmented species (especially *Achorutes armatus* and *A. nivicolus*) were lower down. It is probable these animals migrate to the lower layers as the rising sun dries out the upper layers, and back to the upper layers as the sun sets and the forest floor becomes cool and moist (dewy). Thus the lower layers would act as a retreat during periods of drought for many of the springtails. These daily migrations would account in part for the variation in numbers per sample of litter.

Holdhaus (63) reports such daily vertical migrations of the soil fauna in the upper alpine zone under the influence of the sun's rays. In the forest he found the fauna of the topsoil decreased somewhat in numbers on hot days, but there was no general migration. Bettles were found more numerous at night than by day, but he has no proof that this was due to migration to lower soil horizons. Volz (93) found no marked daily migration of springtails in the flood plain (deciduous) woodland. This he attributes to the leaf layer which remains relatively saturated with water even in the summer [and German summers are apt to be pretty wet]. In the pine forest soil, however, he found evidence of migration from the litter into the raw humus at least during warm dry weather. This he attributes (in part) to the great pore space (88 per cent) of the raw humus.

In brief, therefore, one may conclude that in dry woodlands, in a relatively dry climate, there may be general migrations, but in moist woodlands (especially deciduous) in moist climates there would be practically no daily migrations. In other words, daily vertical migrations of Collembola (and other soil microarthropods) seem to be chiefly conditioned by the degree of change in the humidity of the litter layer, due to degree of solar radiation and degree of dew "fall" at night.

Another factor influencing such a migration would be the nature of the fauna itself. This has been brought out by Marie Hammer (57) in her studies of the soil fauna of Greenland. In brief, irrespective of vegetative cover type (as found in Greenland), if the lower soil horizons are constantly moist, they harbor a moisture sensitive fauna. If the lower soil layers are apt to dry out considerably during some part of the growing season, only dry tolerant species are found. Such species would not be moved to migrate by slight daily changes in humidity. It is the *minimum* condition during the year—and probably also over a cycle of years—which determines the nature of the population, as regards sensitivity and

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indifference. Therefore, what actually occurs at any one locality or in any one type of woodland would have to be determined by an analysis of the population at that place and in that forest type.

Daily vertical migrations in the mineral soil would also depend to a certain extent on the depth and character of the overlying organic (litter and humus) layers, and degree of plant shelter.

Volz is satisfied that frost causes no marked changes in the vertical distribution of Collembola, though there seems to be vertical migrations of a few inches (two to four) with certain species, notably such as *Onychiurus*.

Even though the forest floor and especially the underlying mineral soil is an unusually protected and stable environment, there is wide variation of moisture conditions in the upper *two* inches due to differences in crown density, number of strata of vegetation (openness of the stand), degree of regeneration, degree of fluctuation versus constancy of water table level, distribution of rainfall through the year, especially through the growing season, history of the stand, and degree of pasturage (trampling). Thus Volz should not find evidence of migration between the lower layers, but considerable evidence in the upper two or three inches through every twenty-four hours. The sun shining on one spot for a half hour should cause considerable migration as the litter of that spot warms up under the sun's direct rays. The migration would be particularly active along the advancing periphery of the sunspot. Hence vertical migration may be an extremely local phenomenon, ephemeral and daily. This phenomenon makes deeper samples imperative.

Ingress

A group of animals found in the soil, but not soil animals, are those inhabiting the nests of the burrowing vertebrates. These microcaverns shelter a host of beetles and flies ecologically known as *pholeocoles*. This fauna comprises parasites, commensals, riders of the hosts, and saprophages on nesting material and food refuse, coprophages, mycophages, and predators, parasites and commensals on the saprophages, coprophages and mycophages (42). Those species which enter through the burrow of the host, and which, therefore, do not affect soil structure, are not geocoles.

The same may be said of many myrmecocoles, termitocoles, and inhabitants of the nests of other soil insects (especially bees and wasps).

Competitors and Tolerances

This is as yet a laboratory subject. Very few examples are known in nature. Closely related geocoles live side by side apparently on the same food. They have one great advantage over their laboratory relations—they and the factors of their environment (as circulation) are not limited by the glass walls of a small jar.

CONTROL

The foregoing review would be economically sterile without at least a glance at the social significance of the observed phenomena. Nature is haphazard in some of its end results. Time is of no consideration. Man can hasten natural processes by introducing absent desirables. He has the biota of nearly the entire length of a life zone to choose from.

From the recreational viewpoint, the more wild life we find in our woodlands the more interesting the woodlands become—provided the public discards its childhood fears, and learns what animals (and plants) are really injurious. In New England they are so rare that thirty years of woodland wanderings have not lead me to one of them (poison ivy ex-

cepted). A fundamental principle then is to eliminate nothing that is not positively injurious to man or his well-managed enterprises. Corollary: Control the numbers of only those species which are disagreeable to man when too numerous.

From the point of view of silviculture (the wood crop) the problem is much more complex. After decades of experience the forester has come to realize that mixed stands are better than pure stands—over a long period of time, as for national and state forests. Yet some foresters go about with murderous thoughts for poplars, tulip trees and other lumber-poor species, species albeit which are the most desirable to earthworms, millipedes, molluscs, bacteria and other highly desirable soil animals. In fact, an entirely neglected phase of silviculture is (1) the encouragement of herbs, shrubs and minor trees, the litter of which will sweeten or reduce the acidity of the litter and humus, and thereby generate better soil, (2) the encouragement of herbaceous plants which will annually permeate the soil with dying rootlets which then may be eaten out and leave in their place a divaricating system of water conduits.

Channeling

A compacted soil absorbs but little rain-water which consequently runs over the surface, swells the brooks and streams and causes floods. A soil full of channels takes in the rain-water and distributes it underground. This entering water carries with it into the soil, finely divided organic particles of the litter layer. Thus one of the most desirable soil conditions is a high degree of channeling.

Channeling is brought about in two ways, (1) by burrowing animals, (2) by animals which eat out dead and decaying rootlets (and roots). Every time an annual plant dies its divaricating root system offers a potential irrigation system to the surrounding soil. Hence a carpet of annual plants plus an association of dead-root eating animals are two essentials to good soil channeling.

Any animals channeling the soil by burrowing about in it are desirable, if not otherwise injurious. Some of the damage done by leaf eaters is offset, in the case of species which pupate in the soil, by their burrowing activities. If these species feed on the humbler plants their effect is "all to the good." Some species prefer humbler plants to oaks. A varied flora is thus of greater advantage to the soil than a restricted flora. Grazing of woodlands destroys the herbaceous flora and compacts the soil by trampling. All plants which offer food to insects hibernating or pupating in the soil should be encouraged (except poison ivy).

Mixing

When leaves fall to the ground they become the hosts of various fungi which reduce their contents and make their tissues soft (rotten). In this stage many minute animals are able to feed upon them and further reduce their tissues to minute particles (faeces). If the soil is compacted, these organic crumbs are washed into the brooks and streams and accumulate on and beyond the continental shelf. Far better is it to have this organic residue mixed into the mineral soil. This process is carried on by earthworms, ants, millipedes and some of the mammals, not to mention a host of miscellaneous insects. Not only do these animals push mineral soil out onto the organic layers but some of them draw down into the mineral soil, dead leaves and other organic residues. All such animals should be encouraged—introduced where absent. Many mixers cannot live under an acid litter layer. Therefore all plants, the decaying litter of which tends to alkalinate the litter,

should be encouraged and introduced when absent.

Restocking

Glaciation and forest fires have greatly reduced faunas locally. Such depopulated areas can be restocked by man if done intelligently and with a knowledge of the requirements of the desirable plants and animals. One of our best soil improvers is the European earthworm, called the angle worm or night crawler (*Lumbricus terrestris*). It is an example of the great good obtainable by introducing desirable aliens.

There are, however, some soils which do not favor *L. terrestris*, but they allow *Dendrobaena octaedra* to improve them to such an extent that two or three other species (*L. rubellus*, *L. castaneus* and *D. arborea*) may become established. These species will further improve the soil condition, especially as to humus content, so that *Allolobophora turgida* is enabled to thrive. In this way the soil condition may be built up, at least as to humus content, until it becomes suited to the most desirable—*L. terrestris*. This sequence or succession is outlined by Bornebusch on page 103 (7). It should be noted that mull soil is produced by other worms besides *L. terrestris*. One hears so much about *L. terrestris* because of Darwin's volume, and because its midden piles are spectacular. It is not necessary to confine ourselve to European worms. There undoubtedly are North American species south of the glaciated area which chance has not yet introduced northward. Finally, there are earthworms in northeastern Asia, Argentina and possibly south Africa which would bear investigation as possible allies in soil improvement. We are so ignorant in this field, that we do not even have a serious list of the earthworms of New England (51).

However, earthworms are not the only factor in soil improvement. Elimination of trampling and over-grazing by cows or sheep; encouragement of underbrush and reproduction, especially around the edge of the tract, to reduce dessication by wind action; encouragement of shrubs forming alkaline litter rather than acid; encouragement of under-trees forming alkaline litter; starting a stand with a sprinkling of trees forming alkaline litter (as poplars), but which will later drop out as the desirable trees grow larger; and other such silvicultural management, coupled with the early introduction of certain millipedes, earthworms, and soil-mites, should insure good soil conditions *from the start*. Earthworms and other desirable soil animals as well as sociologically desirable woodland plants should be introduced at the *inception* of a plantation to enable the animals to start litter reduction and humus incorporation before the litter becomes acid. Romell (84, bottom of p. 13) describes how once the soil has been started on the alkaline side, the soil fauna maintain it, but once it gets started on the acid side it will become more and more acid, for the processes involved are cumulative.

Once the fauna becomes established, it will maintain itself by the way it conditions the soil, and by keeping ahead of litter accumulation, especially if the stand is not allowed to become too dense. In this way, by the intelligent use of the most humble plants and animals, which work day and night, and for nothing, soil may be permanently established at its optimum condition of moisture and fertility. Control, especially initial control, is of cardinal importance. Upkeep is barely necessary since the processes are cumulative and effective in the aggregate.

SUMMARY

Soil improvement must take into consideration the soil fauna, the surface animals, and the vegetation in its entirety, for many species in the forest have their particular effect, their contribution, in one direction or another. There is succession in the soil fauna, as there is succession in the flora. Nature's course is haphazard; man can bring about optimum conditions rapidly by enlightened management. He can, not only direct, but hasten nature's processes: (1) by eliminating chance and (2) by using short cuts, and especially (3) by giving the forest complex the right start. At present we have but fragmentary knowledge of the desirable species at hand, and almost no knowledge of the species available from other areas.

[Because of the untimely and lamented death of Dr. Arthur Paul Jacot, while this paper was in the press, the revision and extension of the following bibliography that he had intended to make, could not be accomplished. *Editor.*]

LIST OF LITERATURE

1. Abbott, Cyril E. 1938. The development and general biology of *Creophilus villosus* Grew. *Jour. N. Y. Ent. Soc.*, 46: 49–52, 1 pl.
2. Adams, Charles C. 1915 (Sept.). An Ecological Study of Prairie and Forest Invertebrates. *Bull. Ill. State Lab. Nat. Hist.*, 11 (2), 280 pp., 63 pls., 17 txt. figs.
3. Alexander, Charles P. 1920 (June). The Crane-flies of New York. II. Biology and Phylogeny. *Cornell Univ. Agr. Exp. Stat., Mem.* 38, 1133 pp., 97 pls.
4. Banks, Nathan. 1929. A classification of the Psocidae. *Psyche*, 36: 323–325.
5. Bishopp, F. C., J. D. Mitchell, and D. C. Parman. 1922 (Jan.). Screw-worms and Other Maggots Affecting Animals. *U. S. D. A. Farmers Bull.* 857, 19 pp.
6. Blake, Irving Hill. 1927 (May 21). A Comparison of the Animal Communities of Coniferous and Deciduous Forests. *Ill. Biol. Monog.*, 10 (4): 148 pp., 16 pls.
7. Bornebusch, C. H. 1930 (April 1). The Fauna of Forest Soil. *Det forstlige Forsogsvaesen*, 11: 225 pp., 28 pls., 7 txt. figs.
8. Brade-Birks, S. Graham. 1922 (Feb.). Notes on Myriapoda XXVII. Wandering millipedes. *Ann. Mag. Nat. Hist.*, ser. 9, 9: 208–212.
9. ——. 1929 (July). Notes on the Myriapoda XXXIII. The economic status of the Diplopoda and Chilopoda and their allies. *Jour. Southeastern Agr. Coll., Wye, Kent*, Nos. 26, 27; pp. 178–216, 102–146, 58 figs.
10. Bretscher, K. 1895–6. Die Oligochaeten von Zürich, in systematischer und biologischer Hinsicht. *Rev. Suisse Zool.*, Bd. 3.
11. Bretscher, K. 1899. Beitrag zur Kenntnis der Oligochaeten-fauna der Schweiz. *Ibid.*, Bd. 6.
12. ——. 1900a. Ueber die Verbreitungsverhältnisse der Lumbriciden in der Schweiz. *Biolog. Zentralblatt*, Bd. 20.
13. ——. 1900b. Mitteilungen über die Oligochaetenfauna der Schweiz. *Rev. Suisse Zool.*, Bd. 8.
14. ——. 1900c. Südschweizerische Oligochaeten. *Ibid.*
15. ——. 1900d. Zur Biologie der Regenwürmer. *Biolog. Zentralbl.*, Bd. 21.
16. ——. 1904. Die Xerophilen Enchytraeiden der Schweiz. *Ibid.*, Bd. 24.
17. Brewster, William. 1936. October Farm. *Boston*, 285 pp.
18. Brooks, Fred E. 1919. A migrating army of millipedes. *Jour. Ec. Ent.*, 12: 462–464.
19. ——. 1921 (Nov. 4). Walnut Husk-Maggot. *U. S. D. A. Bull.* 992, 8 pp., 4 pls.
20. ——. 1922 (June 21). Curculios that Attack the Young Fruits and Shoots of Walnut and Hickory. *U. S. D. A. Bull.* 1066, 16 pp.
21. Burgess, A. F., and Collins, C. W. 1917 (July 25). The Genus *Calosoma*. *U. S. D. A. Bull.* 417, 124 pp., 19 pls.
22. Burroughs, John. 1913. The Summit of the Years. *Boston*, 298 pp.
23. Chapman, Paul J. 1930 (Sept.–Dec.). Corrodentia of the United States of America; I. Suborder Isotecnomera. *N. Y. Ent. Soc. Jour.*, 38: 219–403, pls. 12–21.
24. Chittenden, F. H., and Neale F. Howard. 1917 (June 28). The Horse-Radish Flea-Beetle: Its Life History and Distribution *U. S. D. A. Bull.* 535, 16 pp.

25. Cobb, N. A. 1914. The North American free-living Nematodes. *Trans. Am. Micr. Soc.*, 33: 69.

26. ——. 1915. Nematodes and Their Relationships. U. S. D. A. Yearbook for 1914, pp. 456–490.

27. Comstock, J. H. and Anna Botsford. 1916. A Manual of the Study of Insects. 701 pp., 797 figs.

28. Culver, Julian J. 1919 (July 10). A Study of *Compsilura concinnata*, etc. *U. S. D. A. Bull.* 766, 27 pp.

29. Curran, Charles H. 1934. The Families and Genera of North American Diptera. 512 pp., many figs.

30. Cutright, Clifford R. 1925 (Sept.). Subterranean Aphids of Ohio. *Bull. Ohio Agr. Exp. Stat.*, No. 387, pp. 173–238, 6 pls.

31. Daniel, Derril M. 1928 (Feb.). Biology and Control of the Blackberry Leaf-Miner. *N. Y. State Agr. Exp. Stat. (Geneva), Tech. Bull.* 133, 38 pp., 5 figs., 1 pl.

32. Darwin, Charles. 1881. The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits. Murray, 326 pp., 15 figs.

33. Davis, John J. 1917 (Dec.). The Corn-Root Aphis and Methods of Controlling It. *U. S. D. A. Farmers Bull.* 891, 12 pp., 5 figs.

34. ——. 1919 (Feb.). Contributions to a knowledge of the natural enemies of *Phyllophaga*. *Ill. Nat. Hist. Surv. Bull.*, 13: 53–138, pls. 3–15.

35. Diem, Konrad. 1903. Untersuchungen über die Bodenfauna in den Alpen. Dissertation: *St. Gallen*, 187 pp.

36. Eaton, Elon Howard. 1914. Birds of New York. Part 2. 719 pp., 106 pls.

37. Errington, Paul L. 1937. What is the meaning of predation? *Smith. Inst. Rpt.*, 1936, pp. 243–252.

38. ——. 1937 (March). Winter carrying capacity of marginal ruffed grouse environment in north-central United States. *Canad. Field-Nat.*, 51: 31–34.

39. —— and F. N. Hamerstrom. 1936 (June). The Northern Bob-White's Winter Territory. *Iowa State Agr. Exp. Stat., Research Bull.* 201, 443 pp., 26 figs.

40. ——. 1937 (July). Evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. *Jour. Wildlife Manag.*, 1: 3–20.

41. Evans, T. J. 1910 (Sept.). Bionomical observations on some British millipedes. *Ann. Mag. Nat. Hist.*, ser. 8, 6: 284–291.

42. Falcoz, Louis. 1914. Contribution à l' Étude de la Faune des Microcavernes, Faune des Terriers et des Nids. *Lyon*, 187 pp., 38 figs., 1 pl.

43. Fall, H. C. 1924 (Oct.). The blueberry leaf-beetle and some of its relatives. *Maine Agr. Exp. Stat. Bull.* 319, pp. 81–141.

44. Fleming, W. E. and Baker, F. E. 1936. A method for estimating populations of larvae of Japanese beetles in the field. *Jour. Agr. Res.*, 53: 319–331.

45. Folsom, Justus Watson. 1902. Collembola of the grave. *Psyche*, 9: 363–367, illus.

46. Forbes, Stephen A. 1907 (Aug.). On the life history, habits, and economic relations of the white grubs and May beetles. *Ill. Agr. Exp. Stat. Bull.* 116, pp. 447–480.

47. Forbes, Wm. T. M. 1923 (July). The Lepidoptera of New York and Neighboring States. *Cornell Univ. Agr. Exp. Stat., Mem.* 68, 729 pp., 439 figs.

48. Frenzel, Gerhard. 1936. Untersuchungen über die Tierwelt des Wiesenbodens. Fischer, 130 pp., 8 figs.

49. Friend, Hilderic. 1924. The Story of the British Annelids (Oligochaeta). *London*, 288 pp., 57 figs., 1 col. pl.

50. Frisch, John A. 1937. The life-history and habits of the digger wasp *Ammobia ichneumonea*. *Am. Midl. Nat.*, 18: 1043–1062.

51. Gates, Gordon E. 1929 (Sept. 13). The earthworm fauna of the United States. *Science*, 70: 266–267.

52. Ghilarov, M. S. 1937 (Dec.). The fauna of injurious soil insects of arable land. *Bull. Ent. Res.*, 28: 633–637.

53. Gibson, Edmund H. 1916 (June 9). The Corn and Cotton Wireworm in its Relation to Cereal and Forage Crops. *U. S. D. A. Farmers Bull.* 733, 7 pp.

54. Gossard, H. A., and J. L. King. 1918 (Sept.). The peach-tree borer. *Ohio Agr. Exp. Stat. Bull.* 329, pp. 53–87.

55. Hamilton, Clyde C. 1925. Studies on the Morphology, Taxonomy and Ecology of the Larvae of Holarctic Tiger Beetles (Family Cicindelidae). *Proc. U. S. Nat. Mus.*, 65 (17): 87 pp., 12 pls.

56. Hamilton, Wm. 1936 (Aug.). Seasonal food of skunks in New York. *Jour. Mam.*, 17: 240–246.

57. Hammer, Marie. 1937. A Quantitative and Qualitative Investigation of the Microfauna

Communities of the Soil at Angmagssalik and in Mikis Fjord. *Med. Groen.*, 108 (2): 53 pp., 17 figs.

58. Hatch, Edith M. 1912 (Dec.). Aphidae. *Me. Agr. Exp. Stat. Bull.* 207, p. 448.
59. Hayes, Wm. P. 1918. Studies on the life-history of two Kansas Scarabaeidae (Coleoptera). *Jour. Ec. Ent.*, 11: 136–144.
60. Hensen, V. 1877. Die Thätigkeit des Regenwurms (*Lumbricus terrestris* L.) für die Fruchtbarkeit des Erdbodens. *Zeitschr. f. wissensh. Zool.*, Bd. 28.
61. Herrick, Glenn W. 1935. Insect Enemies of Shade Trees. 417 pp.
62. —— and C. H. Hadley. 1916 (July). The lesser migratory locust. *Cornell Univ. Agr. Exp. Stat. Bull.* 378, pp. 11–12; 20–23.
63. Holdhaus, Karl. 1912. Ueber die Abhängigkeit der Fauna vom Gestein. *Verh. intern. Zool. Kongr., Jena*, 8 (1910): 726–745.
64. Houser, J. S. 1912 (Sept.). The wheat leaf-miner. *Ohio Agr. Exp. Stat. Bull.* 251, pp. 79–86.
65. Hyslop, J. A. 1915 (Jan. 27). Wireworms Attacking Cereal and Forage Crops. *U. S. D. A. Bull.* 156, 34 pp.
66. Jacot, A. P. 1935 (Oct.). Molluscan populations of old growth forests and rewooded fields in the Asheville Basin of North Carolina. *Ecology*, 14: 603–605.
67. ——. 1936 (July). Soil structure and soil biology. *Ecology*, 17: 359–379, 3 figs.
68. Jegen, G. 1920. Zur Biologie und Anatomie einiger Enchytraeiden. *Vjschr. naturf. Ges., Zurich*, Bd. 65.
69. Lindquist, Arthur W. 1934 (April). Notes on two *Vespula* nests from Kansas. *Jour. Ent. Soc., Kansas*, 7: 51–55.
70. Lowe, V. H. 1898 (Dec.). Preliminary notes on the grape-vine flea-beetle. *N. Y. Agr. Exp. Stat.* (*Geneva*), *Bull.* 150, pp. 263–265, pls. 6–7.
71. Marlatt, C. L. 1907 (July 18). The Periodical Cicada. *U. S. D. A. Bur. Ent., Bull.* 71, 181 pp., 68 figs.
72. Merker, E. 1926. Die Empfindlichkeit feuchthäutiger Tiere im Lichte. *Zool. Jahrb., Allg. Zool.*, Bd. 42.
73. ——. 1926. Warum kommen Regenwürmer in Wasserlachen um und warum verlassen sie bei Regen ihre Wohnröhren? *Ibid.*
74. Morse, Max. 1904 (May). Breeding habits of the Myriapod *Fontaria indianae*. *Ohio Nat.*, 4: 161–163.
75. Nefedov, N. I. 1930. A quantitative study of the ant population of the Troitsk Forest-Steppe Reserve. *Bull. Inst. Rech. Biol. and Sta. Biol. Univ. Perm.*, 7: 259–291, 8 sets of quadrats.
76. Olson, Henry W. 1928 (Nov.). The earthworms of Ohio. *Ohio Biol. Surv., Bull.* 17, pp. 47–90, 8 figs.
77. Orieux, M. A. 1899. Les Vers de Terre. *Bull. Soc. Sci. nat. Ouest, Nantes*, T. 9.
78. Parrott, P. J. and H. Glasgow. 1916 (Dec.). The Leaf-Weevil. *N. Y. Agr. Exp. Stat.* (*Geneva*), *Tech. Bull.* 56, 24 pp.
79. Pearse, A. S. 1926. Animal Ecology. McGraw-Hill, 417 pp.
80. Phillips, W. J. 1909 (Nov. 30). The slender seed-corn ground-beetle. *U. S. D. A. Bur. Ent., Bull.* 85, pt. 2, pp. 13–28.
81. Rau, Phil. 1928 (June). Field studies in the behavior of the non-social wasps. *Trans. Acad. Sci., St. Louis*, 25: 325–341.
82. Ribaucourt, E., and A. Combault. 1907. Utilité des vers de terre en agriculture. *Bull. Soc. cent. forest., Belgique.*
83. Romell, L. G. 1935 (Jan.). An example of Myriapods as mull formers. *Ecology*, 16: 67–71, 2 figs.
84. ——. 1935 (Feb.). Ecological Problems of the Humus Layer in the Forest. *Cornell Univ. Agric. Exp. Stat., Mem.* 170, 28 pp.
85. Sandon, H. 1927. The Composition and Distribution of the Protozoan Fauna of the Soil. Oliver and Boyd, 237 pp., 6 pls., 3 charts.
86. Stephenson, J. 1930. The Oligochaeta. Clarendon. 978 pp., 242 figs.
87. Stewart, F. C. 1896 (Dec.). The cucumber flea-beetle as the cause of "pimply" potatoes. *N. Y. Agr. Exp. Stat.* (*Geneva*), *Bull.* 113, n.s., pp. 309–317, pl. 1.
88. Stoner, Dayton. 1937 (Nov. 19). Three returns of a bank swallow. *Science*, 86: 469–470.
89. Tansley, A. G. 1923. Practical Plant Ecology. Dodd Mead, 228 pp., 15 figs.
90. Thoreau, H. D. 1881. Early Spring in Massachusetts. Houghton, 354 pp.
91. ——. 1884. Summer. 382 pp.
92. Verhoeff, Karl W. (no date). Oberklasse: Progoneata. *In:* Brohmer, P., P. Ehrmann, G. Ulmer. Die Tierwelt Mitteleuropas. Bd. 2, Lief 3, 90 pp., 114 figs.
93. Volz, Peter. 1934 (Dec. 8). Untersuchungen über Mikroschichtung der Fauna von Wald-

böden. *Zool. Jahrb., Abt. Syst. Oek. Geog. Tiere*, 66(3/4): 153–290.

94. Voris, Ralph. 1934 (Dec. 31). Biologic investigations on the Staphylinidae (Coleoptera). *Trans. Acad. Sci., St. Louis*, 28: 233–261.

95. Walden, B. H. 1911. Orthoptera of Connecticut. *Conn. Geol. and Nat. Hist. Survey Bull.* 16, pp. 48–169, pls. 6–11.

95a. Watson, J. R. 1934. Thysanoptera of the Geenton. *Fla. Ent.*, 18: 44–46.

96. Warming, Eug. 1909. Oecology of Plants. *Oxford*, 422 pp.

97. Weaver, John E., and Clements, F. E. 1929. Plant Ecology. McGraw-Hill, 520 pp., 262 figs., 1 pl.

98. Weese, A. O. 1925 (Feb. 7). Animal Ecology of an Illinois Elm-Maple Forest. *Ill. Biol. Mon.*, 9 (4): 93 pp., 7 pls.

99. Weld, Lewis H. 1921. American gall-flies of the Family Cynipidae producing subterranean galls on oak. *Proc. U. S. Nat. Mus.*, 59: 187–246, pls. 28–37.

100. Wheeler, Wm. Morton. 1910. Ants: Their Structure, Development and Behavior.

101. ——. 1916. Formicoidea. *In:* Britton, W. E. Guide to the insects of Connecticut. Part III. The Hymenoptera. *State Geol. and Nat. Hist. Surv. Bull.* 22, pp. 577–601.

102. Whitehead, W. E. 1919. *Proc. Ent. Soc., Nova Scotia*, 1918, pp. 42–46.

103. Wollmy, E. 1890. Untersuchungen über die Beeinflussung der Fruchtbarkeit der Ackerkrüme durch die Thätigkeit der Regenwürmer. *Forschungen auf dem Gebiete der Agrikulturphysik*, Bd. 13.

104. ——. 1897. Die Zersetzung der organischen Stoffe und die Humusbildungen. *Ibid.*, Bd. 19.

SEX DIFFERENCES IN MORBIDITY AND MORTALITY

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INTRODUCTION

THE differences between men and women in relation to the processes that lead to death are of more than passing interest for the student of human constitution. This branch of human biology, it has been emphasized (Pearl and Ciocco, 1936; Ciocco, 1936a, b), has for one of its major objectives to discover and eventually measure the stable organic correlation—integrated biological relations—between the morphological, physiological, psychological, and pathological traits of the individual. Therefore, the differences in morbidity and mortality observed for the two sexes assume special importance not only because the individuals of the two sexes are on the whole also morphologically and functionally differentiated but primarily because the sex dimorphism reflects a dissimilar biological make-up. This, it is of course realized, does not mean that sex differentiation is due simply to the chromosomal constitution of the individuals. In the first place, as Danforth (1932) ably points out, the results of investigations on sex linkage have shown clearly that the so-called sex chromosomes are, one might say, only incidentally concerned with sex differentiation. Besides, as a result of the work of Bridges and of all those who have confirmed and extended his observations (Bridges, 1932), it is accepted that the characteristics of each of the sexes are determined not only by the absence or presence of one of the sex chromosomes but also by the quantitative balance between the number of sex and autosomal chromosomes. The original simple scheme is further relegated into the background when an explanation is sought for Goldschmidt's observations on the alteration of the sex ratio and on the production of intersexes as the result of crosses between certain varieties of tussock moths. The conclusion which Goldschmidt (1917) reached and which he has maintained since (cf. Goldschmidt, 1938), is that "every individual is able to develop into one sex or the other or any stage between; further that every individual contains all the elements necessary for the development of either sex and its attributes; further that these elements or substances must have a certain quantitative relation to each other in order to secure to one of them the control of development; and that the introduction of quantities in a cross which do not fit the given quantity of the other partner set up the sex differentiation in favor of the higher quantity."

That the final differentiation of sex is dependent also on extra-chromosomal factors is universally admitted today, thanks to the many observations and experimentations reported on gynandromorphism and sex reversal. Thus, the observation by Crew (1923) of the broody hen transformed through disease into a potent rooster is well known. Equally familiar are the studies of Hertwig (1906) continued and elaborated further by

Witschi (1934) to demonstrate how the sex of female tadpoles can be reversed. In recent years, due to the increased knowledge about the function of the endocrines and the chemical composition of the hormones, investigations on the subject have multiplied so that now a more comprehensive idea of the complexity of the processes of sex differentiation has been obtained. The general import of these studies has been dealt with in recent exhaustive reviews by Bridges (1939), Willier (1939), Witschi (1939) and Danforth (1939) and need not be considered here. One may sum up, as Danforth (1932) does, by noting that "We may, then, in the present state of our information, think of somatic sexuality as the expression in each individual of a certain grade of development along special lines. In higher forms the grade attained by each person is primarily conditioned by the particular set of chromosomes which are brought together in the fertilized egg and which determine the direction to be taken in development of fundamental potentialities which are common to all. The direction of this development involves the production of the appropriate type of endocrine system, which in turn is largely effective in supplying the necessary stimuli for the realization of the kind and degree of sexuality foreshadowed in the fertilized ovum." Thus, in comparing the morbidity and mortality of the two sexes or—as is usually the case when dealing with man—of persons who differ relative to the conformation of the external genitalia, the final aim is to arrive at a knowledge of the association between liability and susceptibility to specific diseases and the fundamental biological factors which serve to produce the somatic expression of the two sexes. Although there are still many uncertainties about the actual processes leading to sex dimorphism, it is only too evident that humanity could not be segregated so clearly into any two other groups about which the basic factors of differentiation are known in the same degree as is the case for the sexual differentiation into men and women. For this reason particularly, that is, as a new approach to the study of human constitution, this survey of official vital statistics and clinical reports has been undertaken.

THE DIFFERENTIAL MORTALITY IN THE TWO SEXES

Throughout practically the whole life span of man, the rate of mortality of the males exceeds that of the females. In the following tabulation, the life table mortality rates computed by Dublin and Lotka (1936) from data relating to the years 1929 to 1931 illustrate the sex differences in mortality observed in the population of the United States.

It should be noted here that while the figures in Table 1 demonstrate that the mortality of the women is lower than that of the men at all ages, observations in other countries, as well as in the United States in other periods, show that in the early adult life and in the so-called reproductive period women have a slightly higher rate of mortality than the men. Why the life table rates reproduced in Table 1 do not bring out this fact is an item for discussion which will not be gone into at this time (cf. Wiehl, 1938).

The higher mortality of the males has been recognized and quantitatively demonstrated ever since statistical observations on population phenomena have first been made. In his *Natural and Political Observations* (1676) Captain John Graunt reported that more men are born and that more die and that there are more men than women in the population. Yet, he noted, "I have heard physicians say that they

have two Women Patients to one Man, which Assertion seems very likely; . . . Now, from this it should follow, that more Women should die than Men, if the number of Burials answered in proportion to that of Sickness: but this must be salved, either by the alleging, that the Physicians cure those Sicknesses, so a few more die than if none were sick; or else that Men, being more intemperate than Women, die as much by reason of their Vices, as Women do by the Infirmity of their Sex; . . ." Considering the times

TABLE 1

Life table mortality rates of white males and females at decennial ages. United States population of 1930

(Adapted from Dublin and Lotka, 1936.)

AGE (*in years*)	RATE PER 1,000	
	Males	Females
0	60.86	48.21
10	1.45	1.09
20	3.12	2.70
30	4.12	3.74
40	6.79	5.32
50	12.72	9.55
60	26.35	20.63
70	57.33	48.36
80	128.38	116.06
90	255.13	236.62

this is about as clear a presentation of the problem as could be outlined and it is doubtful whether any progress in this respect has been made since, even though Graunt utilizes the findings mainly as a demonstration of the "*Law of Nature*, that is, the *Law of God*" that man should be monogamous.

Another of the founders of demography, Moheau, (cf. Niceforo, 1925) in 1778 published his famous treatise on the French population and in it the usual sex differences in mortality are demonstrated. To Moheau, these findings seemed contrary to expectations because he believed that since the female matures earlier than the male her span of life should be shorter. The higher mortality of the men, he opined in view of the data, must therefore result from the more hazardous and laborious life led by them. Somewhat similar was the conclusion of the contemporary English historian Maitland (1739) who, as quoted by Farr (1885), said: "the majority in favour of the males is by our naturalists said to be designed by nature for the support of that part of the human species which is more liable to be destroyed by War than the other. But as war is only casual, and not perpetual, I am of the opinion that this supernumerary supply is designed by nature as a constant remedy against incessant contingencies which the males are more obnoxious to both by land and water than the females."

In sum, if we disregard the teleological aspect of the discussion, these authors as well as the numerous students of the subject who have followed them see in the higher mortality of the males a consequence of the masculine pattern of living. Undoubtedly this social and environmental factor does play an important rôle in the sex differential mortality but it does not explain the whole of the differences between the two sexes, particularly that associated with death in infancy. Quetelet (1835) was apparently aware of this. As usual, he believed that an irregular mode of living and the ease with which the carnal appetites can be satisfied are responsible for the higher adult male mortality. With regard to infants, however, he somewhat lamely, although in italics, concluded: "Il parait donc hors de doute qu'*il existe une cause particulière de mortalité qui frappe de préférence les enfans mâles avant et immédiatement après leur naissance.*"

As Quetelet and others since have well realized, the higher mortality of the males

in infancy indicates that the aggregate shorter duration of life of men when compared to women can in part only be attributed to the special function of the male in human society. Conceivably other factors must be involved, probably factors which are associated with the inherent biological differences between the sexes. Lending support to such a view are the observations on other animals most of which have been summarized and discussed by Geiser (1923), Parkes (1926), MacArthur and Baillie (1932) and Crew (1937) among others. Of course, precise knowledge about the relative mortality of the males and females of other animals is still not very extensive or conclusive.

With reference to other mammals, the data reported refer mostly to pre-natal mortality and in general are in agreement with the findings about man. The old investigation by Goehlert (1888) which is often quoted found that among horses for every 100 females born dead there are 106 males, while for every 100 females born alive there are only 97 males. The inference drawn from these facts is that the male manifests inferior resistance to the causes of foetal mortality. A similar conclusion is reached from the observations of King (1921) on rats, those of Jewell (1921) on cows, and of Parkes (1925) on pigs. With reference to duration of post-natal life the report of Crew (1925) on pigs is especially interesting. According to Crew, in over 2000 pigs the mortality between birth and weaning was found to be 39 percent of the males and 34 percent of the females.

With regard to birds the weight of evidence would seem to indicate that in general the male is the less resistant of the two sexes. Such is the conclusion reached by Pelseneer (1925) in his review of reports by field naturalists and collectors of wild birds. Although the reliability of this type of information may be questioned it is in agreement with the observations of Cole and Kirkpatrick (1915) on pigeons and of Haig-Thomas and Huxley (1927) on pheasants.

The most extensive information about birds is obtained, as expected, from data on the domestic fowl. With regard to pre-natal mortality no definitive conclusion can be reached from the recent observations reported. For example, Byerley and Jull (1935) found more females than males among the dead embryos, while Crew (1938) found a slight excess of males. On the other hand, Pearl's (1917) careful study of the sex ratio at hatching based on over 20,000 chicks indicates that slightly more females than males are produced, the proportion being 944 males per 1000 females. Moreover, it is important to note that his data show that for the embryos dying between the tenth day of incubation and hatching the sex ratio is not significantly different from that of the live births. He therefore concludes that for the fowl generally "prenatal mortality is not differential in respect to sex." With regard to post-natal mortality, however, it would seem that a sex differential exists. According to the studies of Landauer and Landauer (1931) and of MacArthur and Baillie (1932) there is a consistently higher male mortality at least for the first 17 weeks after hatching.

Geiser (1923) who "ransacked the literature" on fishes noted that for the plaice (*Pleuronectes platessa* L. and *Hypoglossoides platessoides* Fahr.), the witch (*Pleuronectes cynoglossus* L.), the salmon (*Salmo salar* L.), the smelt (*Osmerus eperalanus* L.) and the dogfish (*Spinax niger*) the data recorded indicates that the male has a shorter life span than the female. The conclusion reached is based

on the fact that the proportion of males caught is higher in the younger than in the older fish. Of a more precise if not yet satisfactory character are the data reported on the top-minnow, *Gambusia holbrooki* Grd. Geiser (1921) showed for this species that the rate of mortality during a short period of observation was higher for the males than for the females.

Passing to the insects, one finds that in these forms also the males probably have a shorter duration of life. Incidentally while reports on a fairly large number of species have been made with reference to the relative death rate of the two sexes the samples on which they are based are really too small to give reliable results.

There are extensive observations, however, concerning the codling moth (*Carpocapsa pomonella*) and the fruit-fly (*Drosophila melanogaster*). For the former, the tabulations that MacArthur and Baillie (1932) have made of the data published under the auspices of the U. S. Department of Agriculture for many years point to a shorter mean duration of imaginal life in the male. The same is true for *Drosophila* according to the experiments recorded by Pearl (1928). Pearl's analysis which utilizes the actuarial technique indicates that under all conditions of laboratory experimentation the females survive longer than the males.

In sum, from this brief and necessarily fragmentary review of the available and reliable data on the subject, it appears that a lower resistance of the male to the processes leading to death is not peculiar only to man, but is found in other animals as well. To explain this phenomenon so general in nature a number of hypotheses have been introduced such as that it is due to the existence of a sex-linked recessive factor, a sex-limited factor or to differences in metabolism. None of these theories is satisfactory either because there are too many discrepancies between facts and theory or else the supporting evidence is not probative.

When one examines soberly the phenomenon under consideration and the inquiries which have been made to determine its causes, it will be immediately apparent that one of the most obvious elements of the problem of mortality has been overlooked. This is, that there are many ways of dying as Pearl (1922) emphasizes, quoting well from Seneca:—nascimus uno modo multis moriur. More than one of the organs and organ-systems of the body can break down and cause death and until the characteristics of those processes that cause death of the males and of the females are adequately known it seems rather idle to speculate regarding the factors responsible for the apparent inferior survival value of the male. The importance and relevance of this point will become clear, it is hoped, in the survey here presented of the causes of death of men and women of the United States, particularly.

PRENATAL MORTALITY

It has long been established that in man as well as in some other animals (*vide supra*) foetal mortality is higher in the male. The preponderance of male deaths is, for man at least, greatest during the early period of uterogestation and decreases with duration of pregnancy. This phenomenon is well illustrated by the following tabulation made by Ciocco (1938b) of the stillbirths and abortions reported from 1925 to 1934 in a selected birth registration area of the United States. In Table 2 the sex ratio (number of males per 1000 females) has been included in homage to a time-honored custom. Actually the statistical analysis has been based on the masculinity

rate $= \frac{100 \text{ males}}{\text{males} + \text{females}}$ which seems preferable from many standpoints.

During the years from 1925 to 1934, there were more than 180,000 stillbirths and abortions of recognized sex registered in the selected area of the United States. Of these, 57.1 percent were males, giving a sex ratio of 1330.3. The proportion of males decreases rapidly from the second month to the fifth, then the decline is gradual until a minimum is reached at 7 months. Thereafter there is a slight increase. The monthly variation demonstrated in this table is apparently not a random fluctuation of the sex ratio for the total because the Lexis coefficient indicates that the standard deviation of the monthly fluctuations of the masculinity rates is more than ten times the standard deviation of the masculinity rate of the total.

TABLE 2

Masculinity rate and sex ratio of stillbirths that were registered between 1925 and 1934 in a selected area of the United States. Classified according to period of uterogestation

(From Ciocco, 1938 b.)

PERIOD OF UTEROGESTATION (*in months*)	MASCULINITY RATE	SEX RATIO	SEX RECOGNIZED IN	
			Number	*Percent*
Under 2	69.5	2280.0	82	10.1
2	81.2	4311.3	563	27.8
3	78.3	3610.0	2388	63.2
4	66.8	2012.2	6401	89.5
5	58.3	1396.1	12541	97.4
6	55.1	1227.4	17857	99.0
7	52.7	1124.0	23109	99.4
8	55.5	1247.5	28903	99.6
9	57.4	1346.9	68932	99.8
10 and over	57.1	1332.8	2671	99.6
All stillbirths including those of unknown period	57.1	1330.3	181548	96.9

The trend of the sex ratio by month of uterogestation as observed here is in good agreement with that reported by Auerbach (1912) on stillbirths and abortions in Budapest, and by Tschuprow (1915) on those of Budapest, Vienna and Paris. Schultz (1921), who has discussed this question in detail, believes that the high masculinity noted in the early months of uterogestation as deduced from official vital statistics is probably exaggerated due to error in recognizing the sex of the foetus in the early stages of intrauterine life. In his collection of over 1400 foetuses deriving in the majority from spontaneous abortions he found the sex ratio equal to 1210 in the third month, 1175 in the fourth, 1096 in the fifth, 875 in the sixth, 1085 in the seventh, 1333 in the eighth and 1676 in the ninth and tenth months. For the months preceding the seventh, these figures are markedly below those shown in Table 2. A glance at that table, which also gives for each month the percentage of stillbirths in which sex was recognized, clearly indicates the difficulty encountered in sexing the individual and emphasizes, in agreement with Schultz, that the sex ratio in the early months of uterogestation is open to doubt. However, it is the opinion of most students, including Schultz, that among the antenatal deaths masculinity is at a minimum from the 5th to the 7th month and higher in the preceding and subsequent periods. A dissenter from the consensus of opinion is Boldrini (1930), who notes that among the very young embryos collected in the Carnegie Institution and described by Streeter (1920) and by Spaulding (1921), there are more females than males. Assuming that the collection of these two observers is a random sample of abortions he concludes that actually more females than males die in the very early periods of pregnancy, and that the difference is such that it more than balances the subsequent relative

higher masculine mortality. Or, in other words, Boldrini accepts the concept of modern genetics that the probability of conception is equal for males and females, and believes that the preponderance of males at birth is a consequence of the relatively high female mortality which takes place in the first two months of pregnancy and which is never balanced by the later excess of deaths among the males. Boldrini's tentative conclusion is considerably weakened by the fact that a study by Wilson (1926), also on material collected in the Carnegie Institution, reveals that histological examination of the embryo is often in disagreement with the diagnosis of sex made by external examination. A considerable margin of error in the sexing is noted especially for embryos already labelled females and which his observations revealed to be males. In view of this, the basic evidence from which Boldrini draws his conclusions is not absolutely reliable. However, as has been pointed out (Ciocco, 1938a) some such conclusion is necessary in order to explain the sex ratio if it is true that the same number of males and females are conceived. No other facts have ever been presented to substantiate a theory based on a preponderant female mortality in the early period of uterogestation and even if it is assumed that the official vital statistics of intrauterine deaths up to the fourth month of uterogestation are grossly erroneous and unreliable relative to sex, there seems to be no doubt that from the fifth to the seventh month there is a decline in the masculinity rate and that the monthly fluctuations of the masculinity rates from the fifth to the tenth month are greater than would be expected if chance alone were operating. All of this expresses the fact that the pattern of the duration of intrauterine existence is different among stillbirths of the two sexes.

Of the factors that contribute to a different behavior of the two sexes with respect both to the frequency of intrauterine mortality and its pattern relative to duration of uterogestation, those included in the list of the causes of stillbirth are the ones which to a certain degree should throw some light on the significance of these observations. Any such expectation, however, has limitations, since the official list of the causes of stillbirths actually is concerned more with the environmental factor, in this case the mother, than with the pathologic state of the foetus. Moreover, for over 25 percent of the stillbirths in this sample the causes were not specified or were unknown. Omitting them and limiting the observations here only to the major categories of stated causes, and truly to those for which the sample is sufficiently large, the results shown in Table 3 are obtained.

Table 3 presents the masculinity rates of the stillbirths according to the more important major categories of causes of foetal deaths as observed, and when correction is made for the time of uterogestation when the foetus was expelled. This correction is necessary because it has been shown (Ciocco, 1938b) that the differences in the distribution of the male and female stillbirths in general exist independently of the causes of death. The correction has been applied by making the distribution of the time of foetal expulsion for the deaths from each cause equal to that found for all deaths.

From the uncorrected data of Table 3, it appears that masculinity is lowest for Malformations; in particular for Spina bifida for which the sex ratio is 560 and "Other" malformations with a sex ratio of 624, while for Hydrocephalus, the sex ratio equals 1108. Among the important causes the highest sex ratio occurs in stillbirths due to Difficult labor—it reaches a

maximum of 2259 for stillbirths accompanying Version. When the usual statistical procedure is applied to determine whether the fluctuations of masculinity rates for each cause category can be regarded as chance deviations from the masculinity rate for all causes, it is found that the masculinity rates for Malformations and Albuminuria *et al.* are significantly lower than that for the total of all causes. The first category includes Hydrocephalus, Spina bifida and "Other" malformations. For all these subdivisions the masculinity rate is significantly *lower* than that of all causes. The same is true for stillbirths due to Albuminuria, Toxaemia and Eclampsia, subdivisions of the Albuminuria *et al.* category, but it is not true for stillbirths due to Nephritis which are also included under this general heading. The major categories of causes of stillbirths which have a masculinity rate significantly *above* that of the total are Abortions *et al.* (but not the subdivision "Other premature"), Prolapse and compression of cord (true only for Prolapse), Malpresentation, Traumatism and overwork (excluding blow, fall, shock and overwork) and Difficult labor. The last class includes stillbirths associated with Deformed pelvis, Instrumental delivery, Version and "Other"; for all of these the masculinity is significantly high compared to that of the total.

TABLE 3

Crude and corrected masculinity rates for the more important categories of causes of foetal mortality

(Adapted from Ciocco, 1938 b.)

CATEGORY OF CAUSES	MASCULINITY RATE		NUMBER OF STILLBIRTHS
	Crude	Corrected for differences in utero-gestation duration	
Malformations	42.8	42.7	9,262
Albuminuria and other diseases incident to pregnancy	53.9	54.8	11,031
Death in utero	56.7	56.8	6,969
General diseases	57.0	56.9	6,255
Diseases of the placenta and membranes	57.1	57.2	18,144
Asphyxia of child (cause not stated)	58.1	58.1	6,495
Prolapse and compression of cord	58.1	58.1	16,756
Malpresentation	58.8	59.1	8,357
Abortion, miscarriage, premature birth	59.3	55.8	12,040
Traumatism and overwork	59.6	58.3	5,116
Difficult labor	62.7	61.0	15,755
All specified causes	56.9	56.9	127,334

When the correction is applied the rank of the masculinity of the several causes remains about the same with but the one notable exception due to the considerable drop of the masculinity rate of Abortions *et al.* This has occurred because the weighting used in the correction has reduced considerably the effect of the high masculinity of those who died at 4 months and under and who constitute a considerable bulk of the stillborn listed in this group. It appears then that, duration of uterogestation being made uniform, the masculinity of stillbirths and abortions varies with respect to the major groups of causes of stillbirth in the following manner:

1. Masculinity is the lowest for stillbirths said to be due to Malformations. In fact more females than males are among the stillbirths included in this group of causes and consequently the masculinity for this group of 42.7 is far below that of the live births, which was 51.4 for the United States in the same period.

2. Stillbirths included in the Albuminuria group have a masculinity rate of 54.8 which is slightly higher than that for live births but lower than the stillbirth mascu-

linity rate from all causes in this selected area.

3. The masculinity rates of stillbirths apparently due to general diseases such as Syphilis, Diseases of placenta and membranes, Asphyxia of child (cause not stated) and to Traumatism and overwork or those included under the category of Death in utero and Abortions ("Other premature") do not differ significantly from the masculinity rate of the stillbirths from all causes. The same is probably true of stillbirths due to Prolapse and compression of cord. The masculinity for this group of causes, it will be noted, is remarkably close to that for Asphyxia (cause not stated). These two categories presumably produce foetal death in a similar manner.

4. The two groups of causes of stillbirths associated with parturition—Malpresentation and Difficult labor—have definitely the highest masculinity rates. In the latter group are included practically twice as many males as females, the masculinity rate being equal to 61.0.

The outstanding characteristics of the pattern of male and female foetal mortality derived from the above statistics are found also in the data that Bundesen and his associates have collected on stillbirth mortality. In an elaborate investigation which is rather unique for its thoroughness, Bundesen *et al.* (1937) have performed post-mortem examinations routinely on as many stillbirths as possible in the Chicago area. Their findings in relation to the sex of the deaths have not been published as yet but through the courtesy of Dr. Bundesen, to whom this writer wishes here to express his thanks, the needed information has been made available for this paper. During the years 1936 and 1937 Bundesen *et al.* performed satisfactory postmortem examinations on close to 1000 stillbirths. In Table 4 are given the masculinity rates in relation to the major classes of pathologic diagnoses as grouped by these investigators.

It is to be noted first of all that of the total 985 stillbirths examined 524 are males giving a masculinity rate of 53.20. This is lower than that found for the total registration area, but much higher than the masculinity rate for live births. From the standpoint of this study, the most important finding is that the lowest masculinity rate is associated with deaths due to malformations and tumors, while the highest occurs in the hemorrhage and injuries group. Of great interest is the category that includes stillbirths where no organic lesion could be found at autopsy. In this category, it will be noted, fall almost one-half of all the stillbirths. The question arises: do these represent "bad eggs," that is *constitutionally defective* individuals? Does the fact that for this group the masculinity rate equals the rate of all the stillbirths have any significant bearing upon the riddle of the sex ratio at conception? To pursue this aspect of the problem in more detail would take us too far afield, but it is to be emphasized that when an experienced observer is unable to find any visible organic reason for the death of about one-half of the stillbirths one is justified in assuming that for these

TABLE 4

Causes of death in male and female stillbirths. Results of satisfactory autopsies made on an unselected sample of foetal deaths occurring in Chicago in 1936 and 1937

(Data supplied by H. N. Bundesen.)

CAUSE OF DEATH	NUMBER OF STILLBIRTHS	MASCULINITY RATE
Malformations and tumors	97	41.2
Infections	32	46.9
No pathologic lesion	480	53.8
Asphyxia	213	55.9
Hemorrhage and injuries	163	56.4
All deaths	985	53.2

deaths the constitutional factor is highly important.

The main conclusion to be drawn from these data is that when stillbirths are grouped according to the presumed cause of death there is a significant variation in the sex ratio of deaths from each cause. Females predominate when the foetal mortality is essentially the result of defective embryonic development, a part of which cases certainly rests biologically upon defects in genetic constitution. On the other hand, masculinity is high when either the placental structure is faulty or is inadequate to safeguard the foetus from toxic elements transmitted by the mother. Finally, masculinity is highest when still births result from a combination of environmental factors, among which the relative size of the foetus in proportion to that of the birth canal is very important. These facts do not appear to support the general assumption that the male is inherently weaker and certainly cannot be used to bolster Lenz's (1931) views that there is in the high masculinity of stillbirths evidence of the action of a lethal gene. Riddle's (1927) theory that the phenomenon is a consequence of maladaptation of the male embryo to the female environment is not contradicted by these findings. However, on the basis of the observations alone it would seem safer to say with Pfaundler (1936) that this phenomenon is the effect of both genetic and environmental factors, particularly when it is considered that the preponderance of males among stillbirths resulting from defective placental structure or from trauma at labor may well be regarded as the consequence of the difference in the rate of physical development between the two sexes.

POST-NATAL MORTALITY

The clinically recognizable conditions that can bring about the death of an individual are many. Over two hundred are listed in the International Classification alone, and it is on the basis of this list that official vital statistics are prepared. For the purpose of this study, a regrouping of the causes of death presented in the official reports will be made so as to bring together all the fatal entities which cause death because of the functional breakdown of a particular organ-system. Such a grouping is embodied in the procedure developed by Pearl (1920) who set up the following classification:

I. Circulatory system, blood, and blood-forming organs.
II. Respiratory system.
III. Primary and secondary sex organs.
IV. Kidneys and related excretory organs.
V. Skeletal and muscular systems.
VI. Alimentary tract and associated organs concerned in metabolism.
VII. Nervous system and sense organs.
VIII. Skin.
IX. Endocrinal system.
X. All other causes of death.

With some modification this classification will be employed here to illustrate, on the basis of the 1930 mortality of the white population of the United States, the degree and direction of the differences between the sexes. The modifications concern the items Premature birth and Injury at birth, both of which Pearl includes in class III and are here considered apart; and the item Violent and accidental deaths which is here discussed separately from category X of Pearl's classification.

With the exception of class III for each of the biological groups of death causes listed above the sex differences in the rate of mortality have been computed and are shown in Table 5. The rates are based on the number of deaths per 100,000 males or females exposed to the risk of dying in

1930. For reasons which need not be gone into here the number of exposed to risk used in these computations is composed of (a) the white population of age 1 year and above as enumerated by the census of 1930, and (b) the number of white births of that year in the registration states.

The deaths due to a break-down of the primary and secondary sex organs have been omitted because with two exceptions they include causes that concern respectively either the males or the females only. Obviously for these organs peculiar to the male sex, the prostate for example, the mortality is restricted to the males; while for diseases involving the ovaries and uterus the mortality is all attributed to the female sex which also dies from unique conditions such as other puerperal hemorrhage, abortions, puerperal septicemia and pyemia. Altogether for this group of causes the females have the higher mortality rate, exceeding that of the males by 44.6 per 100,000.

The findings presented in Table 5 indicate for what group there is an excess of male deaths and therefore how much each organ system contributes to the total excess male mortality. From Table 5, when all the listed causes of death are considered, it is seen that 7 of the 8 groups exhibit a higher male mortality and only one—endocrinal system—has a superior female mortality. It is seen, moreover, that the deaths due to a break-down of the circulatory system contribute most to the excess male mortality, followed in order by the deaths referring to the respiratory system and to the nervous system and sense organs. Least of all is the higher male rate augmented by deaths from the break-down of the skeletal and muscular systems. The order of these differences, it should be noted, is practically the same as that of the frequency of the several groups of causes of death. A break-down of the circulatory system is responsible for the highest number of deaths and it contributes most to the excess male mortality, while deaths from a break-down of the skin, sleletal and muscular systems are relatively few and for these the differences between the mortality of the males and females are small. The outstanding fact to emerge from this tabulation is the reversal of the usual higher male mortality

TABLE 5

Sex differences in the rates of mortality (per 100,000) from the several biological groups of causes of death (excluding primary and secondary sex organs). White populations of the United States Registration Area, 1930

ORGAN-SYSTEM	INCLUDING ALL LISTED CAUSES OF DEATH		INCLUDING ONLY MAJOR* LISTED CAUSES OF DEATH	
	Number of death causes	Differences in rates**	Number of death causes	Differences in rates**
Circulatory, blood	35	+50.2	15	+47.8
Respiratory	23	+34.2	11	+31.0
Nervous, sense organs	28	+33.5	14	+33.0
Alimentary tract	37	+25.6	17	+24.7
Kidney and excretory	11	+8.9	6	+6.9
Skin	11	+1.9	2	+1.4
Skeletal, muscular	12	+0.5	2	−0.8
Endocrinal	7	−13.0	2	−11.4

* Cause of death of at least 1000 males or females, respectively, during 1930.

** + indicates rate higher in males, − indicates rate higher in females.

in the case of deaths due to a break-down of the endocrinal system. Therefore, as has been seen relative to pre-natal deaths, there are conditions for which the females and not the males manifest the higher mortality. In view of this, the question may be raised whether within each group there are only certain specific causes of death for which the males exhibit a higher mortality or whether this is true for all causes. In order to arrive at a definite answer to this question it is necessary to limit the inquiry to those causes of death involving an adequate number of persons. When the investigation on this point is limited to those causes of death stated to be responsible at least for either a thousand male or else one thousand female deaths during 1930, the net changes in the pattern of the sex differences are seen in the last two columns of Table 5. The total number of causes of death to be examined is reduced by almost one-third from 164 to 69 but for each group of causes the amount of the difference between the male and female mortality rates remains about the same. The omission of twenty death causes listed in the circulatory, etc. class reduces the higher male mortality by only 2.4 per 100,000. Similarly, although by this means of selection the number of causes of death included in class VIII (Nervous system, etc.) is lowered by one-half to 14, yet the total male excess is only reduced from 33.5 per 100,000 to 33.0. The only remarkable change produced by the selection of the major causes of death regards the deaths due to a break-down of the skeletal and muscular systems. For these, only 2 out of the 12 causes included have brought about the death of either a thousand males or females and the latter predominate in both instances.

The differences between the male and female mortality rates for the specific major (as defined) causes of death included in each of the eight groups have been tabulated and are shown in Table 6. It is seen from this table that the males have a higher death rate from 52 of the 69 causes listed, 76 percent, while the females have the greater mortality from 17 of the causes. Incidentally, if all the causes of death had been included it would have been found that the males have a higher death rate from 74 percent of the causes. From Table 6 it is also to be observed that for 31, or almost one-third of the listed death causes, the difference between the male and the female rate is equal to less than one per 100,000. These findings would indicate then that the higher mortality of the males is not general but limited to certain causes of death only.

If a difference in rates equal to or greater than 1 per 100,000 is taken as representing an important deviation of the mortality in favor of one or the other sex, it is seen that for 32 major causes of death the males show such an excess, while for 6 the females exhibit the same degree of higher mortality. Considering the causes of death for which there is an excess of male deaths, Table 6 shows that 9 are included in the group of circulatory diseases. In order of male excess, these 9 causes of death are: angina pectoris, chronic myocarditis, other unspecified diseases of the heart, diseases of the coronary arteries, arteriosclerosis, other myocarditis, endocarditis specified chronic and other valvular diseases, congenital malformations of the heart and aneurysms. This list is very interesting both for its omissions and inclusions. It includes all except one of the death causes in which the main pathology lies in the arteries, it includes two of the four listed causes in which the diagnosis specifically implies a break-down of the myocardial layer, but it includes only one of the four items that are based on a diagnosis of a primary defect of the endo-

cardium. The importance of the breakdown of the arteries and myocardium so far as the greater male mortality is concerned is better realized when one considers that the excess of the male rates for

TABLE 6

The major (cf. Table 5) causes of death included in each category of the biological classification distributed according to the difference between the male and female mortality rates (per 100,000)

DIFFERENCE IN MORTALITY RATES (PER 100,000) + = higher rates in males − = higher rates in females	ORGAN-SYSTEM								
	Circ.	Resp.	Nerv.	Ali.	Kid.	Skin	Skel.	Endoc.	Total
− 8.0– 8.9	—	—	—	—	—	—	—	1	1
7.0– 7.9	—	—	—	—	—	—	—	—	—
6.0– 6.9	—	—	—	—	—	—	—	—	—
5.0– 5.9	—	—	—	—	—	—	—	—	—
4.0– 4.9	—	—	—	—	1	—	—	1	2
3.0– 3.9	—	—	—	1	—	—	—	—	1
2.0– 2.9	—	—	—	1	—	—	—	—	1
1.0– 1.9	—	—	—	1	—	—	—	—	1
<−0.9	3	2	1	2	1	—	2	—	11
<+0.9	3	3	8	4	1	1	—	—	20
+ 1.0– 1.9	1	2	2	1	1	1	—	—	8
2.0– 2.9	3	1	—	1	1	—	—	—	6
3.0– 3.9	1	1	1	2	—	—	—	—	5
4.0– 4.9	—	—	—	3	—	—	—	—	3
5.0– 5.9	—	—	1	1	—	—	—	—	2
6.0– 6.9	1	—	—	—	—	—	—	—	1
7.0– 7.9	1	—	—	—	1	—	—	—	2
8.0– 8.9	1	—	—	—	—	—	—	—	1
9.0– 9.9	—	—	—	—	—	—	—	—	—
10.0–10.9	—	1	—	—	—	—	—	—	1
11.0–11.9	—	—	—	—	—	—	—	—	—
12.0–12.9	1	—	—	—	—	—	—	—	1
13.0–13.9	—	1	—	—	—	—	—	—	1
14.0–14.9	—	—	—	—	—	—	—	—	—
15.0–15.9	—	—	—	—	—	—	—	—	—
16.0–16.9	—	—	—	—	—	—	—	—	—
17.0–17.9	—	—	1	—	—	—	—	—	1
Total.....	15	11	14	17	6	2	2	2	69

diseases of the arteries and myocardium constitutes 72 percent of the total excess of the male mortality from diseases of the circulatory system and if the cause "Other unspecified diseases of the heart" is added, as it probably should be, then the percentage rises to 87 percent. The six specific major causes listed in the respiratory group and for which the male mortality is higher than the female by 1 per 100,000 are, in order: lobar pneumonia, tuberculosis of the respiratory tract, bronchopneumonia, cancer of the respiratory tract, other respiratory diseases, influenza, and respiratory diseases complications specified. Interest in this list centers about two facts: First, all the forms of pneumonia except one are listed here. In the second place cancer and tuberculosis of the

respiratory tract are both listed here although they are different in their incidence, particularly with respect to age range. In sum, in this list we find only, or practically only, and almost all the causes that involve a break-down of the lung tissue proper.

The five listed causes of death for which the males have higher death-rates than the females in the nervous system group are, in order: suicide, alcoholism, general paresis, epidemic cerebrospinal meningitis and tabes. These five causes of death are notable because they give some indication of one of the important causes of the differences in the male and female mortality. This is, that the males and females lead a different kind of life. Thus alcoholism and suicide might in a very broad fashion be regarded as different aspects of the same phenomenon related with the personality reaction to the social environment. The stress and strain of social actions is definitely greater for the males than for the females and the differences in mortality relative to alcoholism and suicide might be explained on that basis. Similarly, one notes that tabes and general paresis and epidemic cerebrospinal meningitis are all diseases of an infectious nature and for which the exposure is certainly higher in the males. How much this is responsible for the higher male mortality remains, however, to be seen.

The solitary cause of death with a markedly higher male mortality included in the skin group, is cancer of the skin. Except that it is higher in certain occupational categories of persons the etiology of this type as of other types of cancer is unknown. Obviously, the question here is whether the whole difference in the rates of males and females is not due to the fact that occupations which involve exposure to sun, tars, etc. are statistically speaking male occupations.

Among the causes of death included in Class IV (kidney, etc.), there are three for which the male rate is greater than the female rate by 1 per 100,000 or more. These are: chronic nephritis, cancer of the bladder and nephritis, nephritis unspecified (10 years and over). The excess of males among deaths due to nephritic disease is to be expected due to the higher incidence of the so-called degenerative forms of heart disease. In the group of kidney diseases, is included one of the 19 causes of death for which the death rates of the females are higher than those of the males. This is puerperal albuminuria and eclampsia which may be regarded as the indication of an inferior organization of the kidneys that becomes manifest through the process of pregnancy.

There are eight specific causes of death in the class of diseases of the alimentary tract for which the males demonstrate a higher mortality rate than the females by at least 1 per 100,000. These eight causes of death are a heterogeneous lot consisting of, in order: appendicitis, cancer of the buccal cavity, diarrhea and enteritis (under 2 years of age), ulcer of the stomach, cirrhosis of the liver, cancer of the digestive tract, ulcer of the duodenum and typhoid fever. In this list one notes two diseases in which the chances of infection are important—diarrhea and enteritis (under 2 years of age) and typhoid fever. There are three causes of death representing unknown etiology, namely cancer of the buccal cavity, of the digestive tract, and cirrhosis of the liver; two diseases in which the unknown etiology is associated with psychosomatic changes, namely ulcers of the stomach and duodenum; and finally, appendicitis about which neglect of symptoms is probably the main factor responsible for fatal consequences.

As is shown in Table 6, there are three causes of death in this group for which the

females show a higher mortality than the males. These are: pellagra, other diseases of the gall-bladder and biliary calculi. The first is a nutritional deficiency disease, the second and third are probably associated with the peculiar anatomic structure of the female. The females prevail also in the case of deaths due to endocrine diseases. In this category the two causes of death for which the difference between the mortality rates of the males and females is greater than 1 per 100,000 are diabetes and "other diseases of the thyroid." The females, as seen, have a higher mortality rate from both of these causes.

Summing up this examination of the sex differences in mortality rate according to the biological classification of causes of death and in relation to the specific causes as listed in the official statistics the findings that stand out are:

1. The mortality of the males is higher than the females for the causes of death involving primarily the myocardial layer of the heart, the arteries, and the lungs.

2. To the higher mortality of the males contribute the deaths due to conditions in which is important the reaction to social environment (alcoholism, suicide, stomach and duodenal ulcers); occupation (skin cancer); and exposure to risk of infection (neurosyphilis, epidemic cerebrospinal meningitis, pneumonia, and influenza).

3. On the other hand, the females show a higher mortality than the males as expected from diseases associated with pregnancy and primarily from diseases involving the endocrine system.

Thus the differences between the males and females relative to mortality may be summarized to say that the former exhibit a higher mortality from diseases among which the so-called chronic degenerative pathological processes predominate and from diseases which might be attributed to the social function of the sex, while the females compared to the males show a higher mortality in relation to conditions related to the function of reproduction and in addition manifest striking susceptibility to causes directly or indirectly deriving from a break-down of the endocrine system.

(To be concluded)

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *1901 East Madison Street, Baltimore, Maryland, U. S. A.*

BRIEF NOTICES

EVOLUTION

PAIN, SEX AND TIME. *A New Outlook on Evolution and the Future of Man.*

By Gerald Heard. Harper and Bros., New York and London. $3.00. 8½ x 5¾; xxii + 301; 1939.

Here is the latest work from the prolific pen of a versatile writer. Gerald Heard is better known in America as a lecturer than a writer, though he has produced at least one book that bids fair to gain recognition as one of the significant philosophic contributions of the twentieth century. The present work is a bold attempt to explain some of the more baffling features of human evolution in a novel way. The main premise on which the argument is built is that organic evolution as described in the textbooks is a thing of the past. The clock has run down and the key is lost. Second, that organic life, having lost the power of evolutionary adaptation to environmental change, is doomed to more or less early extinction; and third, that man's superior mentality will enable him to survive by diverting his evolution from an organic to a mental path.

The difference between human and animal mentality, according to this writer is that man contemplates the future. He is time conscious. He forms ideals which lead his evolution onward from above instead of pushing it from below, as do the factors of organic evolution, heredity and environment. Evolution, the author tells us, is accomplished by the expenditure of energy. If the path of evolutionary progress be obstructed the energy must find other outlets, such as pain perception or sexual excitement.

The tendency of the writer to invoke supernatural causes to explain phenomena which might be accounted for on rational grounds will no doubt militate against acceptance of the author's conclusions, which is decidedly unfortunate, as the closing chapters of the work bring a message that the modern world sorely needs. They are a plea for the experimental investigation of practical mysticism, which is the same thing as what most modern writers would call cooperative thinking, but which the patriarchal ecclesiasts designated "the communion of saints."

The book is supplied with copious footnotes, but the lack of an index is a real defect.

THOUGHTS ON EVOLUTION. *II—Evolution and Religion. Anthropological Series of the Boston College Graduate School, Vol. IV, No. 2.*

By Joseph J. Williams, S. J. Boston College Press, Chestnut Hill, Mass. $1.00. 9¾ x 6½; 59; 1939 (paper).

In this brochure the author considers Haeckel and Haeckelism, evolution and religion, the definition of religion, the difference between religion and magic, the origin of religion, and the evolution of religion. The summary of his findings is as follows:

> But we do claim to have disproved the contention of the classical evolutionists who maintain that African tribal religion has evolved according to their theory. So far from there being a gradual rise from polytheism to monotheism, our findings show that there has been a general retrogression in matters of religion and even where tribes have been polytheistic in recent years, there is often a clear indication of monotheistic belief in earlier days.

In the series of studies on *Africa's God* (reviewed in previous numbers of the Q. R. B.) the author's use of numerous quotations with little explanation regarding them was justifiable, since the reader was perfectly aware of the fact that these quotations were answers to a definite questionnaire sent out by the author. However, in the present study the author rambles from quotation to quotation in a manner that does not make at all clear to the reader exactly what he is attempting to set forth.

There is an additional paper on the *Requirements of An Archaeologist* by J. W. Murphy, *S.J.*, in this serial number.

How Life Began. *A Speculative Study in Modern Biology.*

By David Forsyth. William Heinemann (Medical Books), London. 5s. net. $7\frac{1}{4}$ x $4\frac{3}{4}$; xi + 106; 1939.

In his observations on the biology of man, Dr. Forsyth concludes that the main function of the body is to house and mature the germ cells. The difference between male and female gametes is, he speculates, one of positive and negative electricity. Else why the attraction between them?

In the next few chapters of the book there is a discussion of the relation between heredity and environment, the conclusion being that the two merge so closely together as to be given the writer's newly coined term "inherited environment." The Darwinian idea of a harsh and merciless struggle for existence is revolting to the writer. He prefers to think of it not as anything so cruel, but rather as a natural chemico-physical reaction much like the peaceful food-securing activities of plants. But in the reviewer's opinion, called by any sweet name, it's still a struggle.

This speculative treatise contains 21 references in its bibliography.

The Living Thoughts of Darwin.

By Julian Huxley, assisted by James Fisher. Longmans, Green and Co., New York and Toronto. $1.00. 7 x $4\frac{3}{4}$; [6] + 151; 1939.

Probably all biologists have read *The Origin of Species* and most of them *The Descent of Man*. This volume presents condensation of these works in such a form as to dispel for the lay reader the many false ideas that have arisen about Darwinism. Emotional resistance has been built up to such a degree that a clear presentation of the original treatises and equally clear and accurate interpretations of them are necessary for proper understanding by non-scientific readers. Huxley, whose grandfather was such an ardent supporter of Darwin, has given us this book. His comments bring up to date the ideas of Darwin, who labored without such modern knowledge as that of the chromosome mechanism of heredity.

Kiefergebiss und Zähne der Rochen und Haie.

By Karl Jacobi. N. G. Elwert'sche Verlagsbuchhandlung (G. Braun), Marburg a. d. Lahn. RM. 3.50. $10\frac{5}{8}$ x $6\frac{1}{4}$; iv + 64 + 1 chart (paper).

The results of the investigations described and illustrated by numerous photographs and drawings in this study refute Oskar Hertwig's theory that the formation of the cement in human teeth is phylogenetically related to that in the scales and teeth of fish. Differences in the origin and development and distribution of mantle dentin and circumpulpar dentin are shown for the placoidal organs and the various types of teeth of several

species of sharks and rays. The conclusions confirm the criticism of Hertwig's theory made by Jacobshagen in 1923 (*Placoidorgane und Selachierzähne, Heidelberg*). The bibliography includes 29 titles.

GENETICS

AN INTRODUCTION TO GENETICS.

By A. H. Sturtevant and G. W. Beadle. W. B. Saunders Co., Philadelphia and London. $3.25. $7\frac{3}{4}$ x $5\frac{5}{8}$; 391 + 1 folding chart; 1939.

In this scholarly work, the authors have hit a new trend in pedagogy. They have developed a course in the ever-growing field of genetics which follows a logical rather than a historical approach to the subject. Stress is constantly placed upon the fact that genetics is a quantitative science, depending largely upon mathematical analysis and interpretation for its fundamental basis.

The text is written as an introduction to the field, and hence is to be used by students who are coming into contact with genetics for the first time in their lives. From this point of view, it is the reviewer's opinion that there is much that is too theoretical and technical for the beginning student to grasp, even though he may have a fair background in general biology. The problems at the end of each chapter will undoubtedly be an aid in teaching the course, but one wonders whether it would not be better, from the student's point of view, if some of the problems dealt with some actual simple mating problems in *Drosophila*, rather than having all of them confined to technical and mathematical phenomena encountered in theoretical genetics.

The subject matter is intended to deal with the general subject of genetics, but one finds that the space allotted to plants and to animals other than *Drosophila* is quite small. Hence the volume may be described as an excellent treatise on the theory and mathematics of the technical genetics of *Drosophila*.

THE GENETICS OF COTTON.

By Sydney C. Harland. Jonathan Cape, London. 10s. 6d. net. $8\frac{5}{8}$ x $5\frac{5}{8}$; 193; 1939.

This book is written primarily for geneticists. It will also be of interest to growers developing new types of cotton, since it covers rather completely the work done in cotton genetics up to 1937. A fair knowledge of botany and a good knowledge of genetics is required of the reader. The inclusion of illustrations of the phenotypic characters analyzed would be of aid to the student of heredity possessing a limited botanical background.

The subject matter is divided into three main sections and several minor ones. The former are: taxonomy, cytology, and genetics. The latter are: linkage, mutations, hybridization, polyploidy and haploidy, comparative genetics, and evolutionary history. The portion of the book dealing with genetics is especially fine and the outline method used makes for ready reference to any factor treated. The gene symbolism employed is at times obscure but a reading of the paper, *Gene Symbols for Use in Cotton Genetics*, (Hutchinson and Silow, *Jour. of Heredity*, 30 : 461; 1939) by members of Harland's own laboratory will aid the reader. The bibliography contains 209 titles. The table of contents and the index are well prepared.

EXPERIMENTS IN BREEDING HOLSTEIN-FRIESIAN CATTLE FOR MILK- AND BUTTERFAT-PRODUCING ABILITY, AND AN ANALYSIS OF THE FOUNDATION COWS AND OF THE FIRST OUTBRED GENERATION. *U. S. Department of Agriculture. Technical Bulletin No. 677.*

By M. H. Fohrman and R. R. Graves. Government Printing Office, Washington. 15 cents. $9\frac{1}{8}$ x $5\frac{3}{4}$; 81; 1939 (paper).

It was found in 1918 that among dairy-cattle breeders about two-thirds of the cattle were failing to return a profit to their keepers. As a result the Bureau of Animal Industry set up a carefully controlled experiment to afford dairy farmers a better understanding of the laws of inheritance as they apply to milk and butterfat production.

Forty-one foundation cows were bred to a single sire. Detailed reproduction records are given, and also milk and butterfat production of dams and daughters. Analysis shows that the sire had an inheritance for a level of production below that of the three highest-producing dams, but better than that of the lower-producing dams. There is a high correlation between production of dams and daughters, although the daughters show less variability. Final determination of the influence which this sire had on the germ plasm of the offspring will depend upon analysis of production records of the second generation.

AN INTRODUCTION TO MODERN GENETICS. *By C. H. Waddington. The Macmillan Co., New York.* $4.00. 8¼ x 5⅝; 441; 1939.

This excellent text on genetics is unusual in that it proceeds beyond the fundamental Mendelian concepts and the experimental techniques centering about the behavior and mechanics of chromosomes at which point the average text stops. The author then applies genetics to wider problems—development, evolution, animal and plant breeding, and human affairs. Finally, there is a discussion of the nature of the gene. A section on laboratory methods for class work on *Drosophila* is appended to the text. There are two indices—the first by bibliography and author, and the second by subject. The book is amply illustrated with charts, diagrams, photographs and drawings.

GENERAL BIOLOGY

THE ORGANISM. *A Holistic Approach to Biology Derived from Pathological Data in Man.*

By Kurt Goldstein. American Book Co., New York. $4.00. 7⅞ x 5⅛; xvii + 533; 1939.

This is a translation from the German original, published in 1934, but with some changes in the arrangement and a number of additions and omissions. Principally a critical discussion of method, the author nevertheless brings in a wealth of illustrative material (to a large extent his own work on patients afflicted with mental derangements or brain abnormalities, although the work of others is by no means neglected) "essentially supposed to demonstrate over and over again that *method as well as theory must originate from nothing but the most concrete evidence.*" His point of departure is man "primarily because he has found no concept more problematic than the *concept of simplicity.*"

> Even in the analysis of human behavior, the attempt to reduce the more 'complex' performances to the 'simpler' ones has met with the greatest difficulties. Very often, the 'simpler' performances have been found to be abstractions, and the events which the latter aim to explain turn out to be 'simple' only in the presence of a specific, habitual, technical attitude of abstraction. At closer range, however, the 'simple' phenomena have been found to be much more obscure. . . . Such difficulties make one suspicious of attempts to differentiate between 'higher' and 'lower' animals, or to understand the 'higher' in terms of the 'lower.'

In the several chapters the author discusses such matters, among others, as normal ('ordered') behavior and 'disordered' behavior, the nervous system, modification of function due to impairment of the organism, the nature of partitive processes (reflexes, instincts, 'drives'), conception of the organism as a whole, the nature of biological knowledge, and norm, health and disease (including anomaly, heredity, and breeding).

The book is worth study by the biologist, physician, psychologist—in fact all those interested in the study of the nature and behavior of the living organism. Bibliographies are provided for the separate chapters, and there is an index.

BIO-ECOLOGY.

By Frederic E. Clements and Victor E. Shelford. John Wiley and Sons, New York. $4.50. 9 x 5¾; vi + 425; 1939.

Many criticisms have been leveled at ecologists and the science of ecology for falling into the pitfalls of all new disciplines. This, of course, is to be expected, but the most serious fault is that to a considerable extent it still continues in this direction with but little attempt

to rectify the errors which have variously been accredited to "careless observation and experimentation", "lack of intellectual focus", etc. Animal and plant ecology have become so separated that one might think that plants and animals have no influence one upon the other. The definition and numbers of ecological "concepts" have reached meaningless proportions. Fortunately the present book attempts a synthesis of the present state of ecological knowledge by considering both plant and animal ecology together as one subject, which is without a doubt a sensible approach. Ecological nomenclature has been subdued. The two authors are of the highest eminence in their respective fields, and the fact that this book is a product of their collaboration should make it a valuable and informative text, which it is.

A Dictionary of Scientific Terms: *Pronunciation, Derivation, and Definition of Terms in Biology, Botany, Zoology, Anatomy, Cytology, Embryology, Physiology. Third Edition.*

By I. F. Henderson and W. D. Henderson. Revised by J. H. Kenneth. D. Van Nostrand Co., New York. $7.00. 8½ x 5½; xii + 383; 1939.

The original edition of this dictionary contained definitions of about 10,000 terms used in biology and its allies, anatomy, botany, zoology, embryology, cytology and physiology. Some terms in bacteriology and palaeontology were included. In the second edition about 1500 new terms were added while in the third comparatively few were. It was not the authors' plan to list all terms in biological literature—since this would run the work up into a good-size dictionary—but rather to produce a small, handy volume. Students, readers and those having to do with the publication of biological literature will find this a useful book.

Wildlife of the Atlantic Coast Salt Marshes. *U. S. Department of Agriculture. Circular No. 520.*

By W. L. McAtee. Government Printing Office, Washington. 10 cents. 9⅛ x 5¾; 28 + 6 plates; 1939 (paper).

Salt marshes of the Atlantic coast are undergoing intensive draining and ditching in furtherance of mosquito control, and as a consequence much of the salt-marsh fauna and flora is being depleted. McAtee asks that some consideration be given to the conservation of this wildlife. He describes the typical plants, birds, reptiles, and mammals that inhabit such areas to acquaint the layman with the resources of these interesting biological habitats.

The Bulletin of Mathematical Biophysics. *Volume 2, Number 1, March, 1940. Edited by N. Rashevsky. University of Chicago, Chicago.*

This number contains the following papers: A neural mechanism for discrimination: II. Discrimination of weights, by A. S. Householder; An approach to the mathematical biophysics of self regulation and cell polarity, by N. Rashevsky; Contributions to the mathematical biophysics of organic form: I. Formation of cavities in cellular aggregates, by N. Rashevsky; Discrimination between temporally separated stimuli, by H. D. Landahl; Convective diffusion in parallel flow fields, by Gale Young.

HUMAN BIOLOGY

Americans. *A New History of the Peoples Who Settled the Americas.*

By Emil L. Jordon. Illustrated by Edward A. Wilson. W. W. Norton and Co., New York. $3.50. 8½ x 5¾; 459 + 8 plates; 1939.

To say that a book is "ingenious" sounds somewhat awkward, yet this adjective can be very appropriately applied to the work under discussion. The stories of the many peoples who have contributed to the making of modern America have been told and retold, but this is the first time that all of them have been integrated into a simple narrative covering both Americas.

It is now almost universally held that the human species originated in the general vicinity of southeastern Asia, from which point of origin mankind has radiated over the inhabitable world. The first settlers in America came from Asia across Bering Strait, because that was the shortest route. They brought no civilization with them for they had as yet not developed any: the pre-Columbian civilizations of Latin America were indigenously developed. After an interval of five thousand or more years the pathway from Europe to America was discovered, and a new stream of immigrants began to cross the Atlantic, bringing a ready made civilization with them. The American continent became the battle ground of two civilizations, and although the exotic one was victorious many of the indigenous characteristics of America became indelibly grafted upon it.

It is the story of the fusion of these two unrelated cultures to form Saxon and Latin America that the author brings to us in a fresh and stimulating form. In Saxon America the Europeans settled on the Atlantic seaboard, gradually advancing toward the west and pushing the aborigines before them. In Latin America they attempted the simultaneous colonization of the entire continent, making it necessary to assimilate the aborigines instead of expelling them. Thus Latin America had no frontier, and consequently no counterpart of the picturesque personalities that developed along the frontier of Saxon America. A few comparisons may be made; for example, Bartolomeo Las Casas with David Zeisberger, but Latin America had no Heinrich Stiegel, no Cleng Peersen, no Emperor Norton, no Johnny Appleseed.

There is an ample index of fifteen pages, but the book suffers by lack of adequate documentation. The author's fondness for presenting romantic characters in a dramatic light (an admirable trait in an author) leads him to make statements that the careful reader will wish to check before accepting as authentic, but the absence of footnotes precludes this.

The treatment of certain personages leaves much to be desired. Of Anne Hutchinson it is recounted merely that she was expelled from Massachusetts for heresy and was subsequently murdered by an Indian. There is not a word about the significant influence on subsequent history exercised by her and her followers after they had established the colony of Rhode Island. She might better have been left unmentioned entirely.

There is much more that might be said about this comprehensive work, which, despite this criticism is delightful reading. In its pages one meets the makers of history who have long suffered undeserved neglect in this country—Bolivar, O'Higgins, and the only really humanitarian dictator in American history, Don Pedro II. The chapters dealing with the cultural contribution of the Spaniard and the ethics of the Eskimo are quite enlightening, and he who undertakes to read the book is not likely to put it down unfinished.

WE DIDN'T ASK UTOPIA. *A Quaker Family in Soviet Russia.*
By Harry and Rebecca Timbres. Prentiss Hall, Inc., New York. $2.50. 8 x 5½; xiii + 290; 1939.

It is difficult to appraise such a book as this. Harry Timbres did not go to Russia to gather material for a book, or to study sociological phenomena, or to spread propaganda. He went only to render service, and he was one of those peculiar people to whom service is a sacrament.

During the world war the Russian people had had to fight three wars simultaneously—a foreign war against the central European powers, a revolutionary war against the government that had oppressed them and lived off of them parasitically through several centuries, and a civil war against certain of their own leaders who sought to betray them. Victory was finally achieved, but at a terrible cost, which was both physical and spiritual. Then came the blockade, bringing famine and pestilence in its wake.

Into such a scene of devastation as this Harry Timbres felt the concern to go to minister to the victims of the war system. The locality which he selected for the site of his labors was about half way between Moscow and the continental divide. Here

at Marbumstroy he settled in 1937, here he was joined later by his wife and two children, and here he laid down his life within a year, a victim of exanthematous typhus.

The book is the story of the experience of this family pursuing the task of their choice. It was not written to arouse either passion or compassion, but simply to tell what they saw and lived through. The story is related by Rebecca Timbres, for Harry spent all his time after completing his routine at the hospital and laboratory each day in translating medical works into Russian from English, and had no opportunity for original literary activity. Those of his letters which are reproduced have of course not been edited in anyway, and are largely taken up with personal matters of technical detail, that might better have been omitted. But Rebecca's journal is an interesting and significant document, dealing as it does with experimental altruism based on individual initiative. It tells us nothing about the politics or economics of Russia in the mass, but it does tell us what individual Russians think, how they live, and what they do.

CULTURAL RELATIONS ON THE KANSU-TIBETAN BORDER.

By Robert B. Ekvall. University of Chicago Press, Chicago. $1.50. 9½ x 6½; xiii + 87; 1939 (paper).

The author was born on the Kansu-Tibetan border, lived there most of his first fourteen years, return in 1923 as a missionary, and remained there until 1935. His work brought him into close contact with the interesting ethnic groups (Chinese, Moslems, and Tibetans) of this little-known marginal area. Fortunately, the author's excellent memory, acute observations, and ability to present in clear concise manner a mass of detail without losing sight of the more generalized aspects of life on the border have combined to produce an excellent study of inter-ethnic relationships.

Although Ekvall divides the ethnic groups into Moslem, Chinese, and Tibetan, the last named is actually divided into two—the sedentary and the nomadic Tibetans—one racial group presenting two different cultures. These four major groups are described in the following relation to each other: (1) the Chinese and the Chinese-speaking Moslems; (2) the Chinese and the sedentary Tibetans; (3) the Moslems and the nomadic Tibetans; (4) the sedentary and the nomadic Tibetans. Between the Chinese and the Moslems (an Arab-Chinese race worshipping Islam) there is hostility due to racial, religious, and personality differences; between the Chinese and the sedentary Tibetans there is an infiltration of ideas and customs with the result that many Tibetan villages have become Sinicized; between the Moslems and nomadic Tibetans there is a mutual diffusion of traits brought about by constant trade relations and economic usefulness to one another; between the sedentary or agricultural and the nomadic or pastoral Tibetans—people actually of the same race and religion (Buddhism) but of different occupations—there is a marked social differentiation with the nomads in the ascendency.

The study is most interesting for the light it throws upon these little-known races—their modes of subsistence, racial differences, religious differences, language, customs, ethnic heritages, numbers and vitality of population, warfare, economic organization, and their inter-ethnic relations. A problem of especial interest to students of population would be the markedly high birth-rate of the Chinese in definite contrast to the other three groups.

POPULATION AND PEACE. *A Survey of International Opinion on Claims for Relief from Population Pressure. International Studies Conference.*

By Fergus C. Wright. International Institute of Intellectual Co-operation, Paris; Columbia University Press, New York. $2.00. 9¼ x 6⅛; xvi + 373; 1939.

This work deals primarily with peace, and with population only insofar as it affects peace. In its method of approach it has more in common with Henri Van Etten's *Pax Oeconomica* (which discusses peace but not population) than with

Carr-Saunders' *World Population; Post Growth and Present Trends* (which discusses population but not peace) despite the fact that Carr-Saunders is quoted over 500 times and Van Etten not at all. The rapidity with which political history is developing is indicated by the discussion of population problems in Austria, Czecho-Slovakia, and Poland, which no longer exist as sovereign states.

According to the findings of the Committee which prepared this book, the only countries in which overpopulation is likely to lead to war are Germany, Italy, Japan, and Poland. In the first of these the process of industrialization has been completed, and the need for colonies to which the surplus population may be exported is acutely felt. Of course there have been many underpopulated nations that have been glad to accept German immigrants in the past as rapidly as they could be assimilated, but present day Germany does not want her emigrants assimilated, she wants them to surrender their residences in Germany but to retain their allegiance to the German flag. The industrialization of Italy and Japan have been only partly accomplished and its continuance will care for the increasing population of these nations for some years to come. But industrialization calls for raw materials, and the conquest of Ethiopia by Italy was intended to supply to the latter a region thought to be rich in natural resources. The great need of Japan is not raw material but markets for finished products, and the densely populated Korea and Manchukuo met this need much better than a sparsely populated region (for example, Australia) ever could have done.

From these considerations it appears that there can be no panacea for relief from population pressure, but that each case must be dealt with separately. The International Studies Conference of the League of Nations to whose researches this book is due have been seeking for four years to learn which nations are suffering from this complaint, to what extent, and what palliative measures may be applied; but they have formulated only a very fragmentary answer to these questions.

The book has 36 pages of bibliographic references, but only 10 of index. Incidentally it is not made clear why Japan and Germany continue to be represented on the Committee after their withdrawal from the League.

SOME MEMORIES OF A PALAEONTOLOGIST. *By William Berryman Scott. Princeton University Press, Princeton.* $3.00. 9 x 6; [7] + 336; 1939.

The author of this work celebrated his 80th birthday in 1938. The book is the story of a long and interesting life that began back in the pioneer days of American science and has continued active up to the present. All the leading intellects of the world not only in paleontology but also in other fields of biology and geology parade in orderly fashion across the pages of this remarkable book—Ameghino and Moreno of Brazil; Gegenbaur, Bütschli, His, Zittel, and Weismann of the German Empire; Milne-Edwards of France; Huxley, Tyndall, Owen, Woodward, Balfour, Sedgwick, Lankester, Mosely, Thompson, Geikie, and Bateson of Great Britain; Dawson of Canada; as well as the Americans Leidy, Cope, Marsh, LeConte, Dana, Gray, Henry, Young, Mitchell, Keen, Merriam, Dall, Ortmann, and Scott's most intimate friend from college days on, Henry Fairfield Osborn. Scott regarded Cope as perhaps the greatest genius he ever met. He adds some more matter, useful for the record, to the account of that remarkable person Othniel C. Marsh, but it becomes increasingly clear that the whole story will never be told in print. Both Osborn and Scott, who probably knew more about it at first-hand than anyone else, suffered from the inhibitions that are associated with being gentlemen, and in their autobiographies exhibit a reticence at certain points that does credit to their humanity, but demonstrates once more that the history of scientific matters is no more likely to be written with scientific precision and completeness than is any other kind of history.

Scott's career is one of great significance, and it is to be hoped that some day his life will be written as it deserves to be, for

he was too close to himself to view himself in the proper perspective. When that time comes the present work will be an excellent source of material, for it is rich in reminiscences of fossil hunting expeditions to the Middle West in which a loquacious nephew of Jim Bridger figures prominently, of years spent in study at Heidelberg, of conventions of the world's leading scientific organizations, and of social contact with men of letters like Charles Godfrey Leland, John Bach MacMaster, James Bryce, Oscar Wilde, Jules Jusserand, and Woodrow Wilson. There is an index of 14 pages.

LESTER F. WARD, THE AMERICAN ARISTOTLE. *A Summary and Interpretation of His Sociology.*
By Samuel Chugerman. Duke University Press, Durham. $5.00. 9 x 6; xiii + 591 + 4 plates; 1939.

The stated purpose of this book is to rescue the memory of Lester F. Ward (1841–1913) from the neglect of the present generation of sociologists. The aim is laudable because Ward was undoubtedly a man of superior intellect. He occupied a high position among paleobotanists, possessed a unique command of scientific terminology and was accepted as a foremost student of sociology when this branch of learning first began to separate from the metaphysical trunk to which it is still closely adherent. As a sociologist Ward was actually a follower of Comte pleading for a new social order along the lines of the Platonic Republic. Pitted against the teachings of Sumner, Ward's feeble and naive attempts at social welfare never advanced far and at his death were more or less immediately forgotten. Chugerman believes that this state of things should be remedied and in one swoop raises him to the intellectual Olympus along side of Aristotle, Darwin, Kant and similar ranking gods. The reason why Ward should occupy such an elevated position is never made clear. The major portion of the book's 600 pages consists of a short biography of our hero, many pages of laudatory adjectives, a critique of the outstanding sociologists and an attempt to find an important place for Ward in the history of human thought. Since the author prefers to tell the reader of the greatness of Ward rather than to demonstate it he is not quite convincing, particularly when he chooses examples of Ward's profound *dicta* such as these: "Matter is what it seems to be" or "1. The object of nature is function. 2. The object of the organism is desire. 3. The object of evolution is activity. 4. The object of man is happiness. 5. The object of society is achievement." The author's wholehearted devotion to his cause is praiseworthy but he would have rendered more effective service to his idol had he controlled the verbal manifestations of his sentiments and proceeded to a sober evaluation of Ward's contributions.

PRIESTS OF LUCINA. *The Story of Obstetrics.*
By Palmer Findley. Little, Brown and Co., Boston. $5.00. 9¼ x 6⅛; xiv + 421 + 32 plates; 1939.

The *Priests of Lucina* is a study of childbirth, medical obstetrics, and midwifery from earliest times on. The author begins by discussing the anatomical proportions of the Venus of Willendorf and "the obstetrical difficulties that must have beset our paleolithic mothers" if this distorted figure were at all representative of prehistoric women. Next are considered the obstetrical practices in the ancient Orient, the fertile land of Mesopotamia between the Tigris and Euphrates Rivers, Egypt, in ancient Judea with its Mosaic laws, Persia, India, China and Japan. From this point on the author treats the history of childbirth and the practice of obstetrics as a history of biographies. The first biography is that of Hippocrates, the star of the Golden Age of Greece, and the last, of John Whitridge Williams, a name revered in the annals of the Johns Hopkins Medical School. A chapter of outstanding interest is that on the Chamberlens and the manner in which they guarded the secret of the "iron tongs", the obstetrical forceps, and the many ways in which they antagonized the College of Physicians from which almost every member of four generations of Chamberlens was expelled

for infraction of one rule or another. "It would appear that the practice of fee splitting is not, as we think, a modern invention, for we find Dr. Peter Chamberlen charged with subsidizing the midwives in lieu of their patronage by offering to build alms houses for 'decayed midwives' and by feasting them with venison, wine and other delicacies." (17th Century.)

The second part of the book consists of studies on the five following subjects: (1) Anatomy, (2) The Forceps, (3) The Midwife, (4) Puerperal Fever, (5) Cesarean Operation. An extensive bibliography and 38 excellent illustrations are included in this study.

CHILDREN OF GOD. *An American Epic. By Vardis Fisher. Harper and Bros., New York and London.* $3.00. 8⅛ x 5⅝; [8] + 769; 1939.

Here is the story of the Mormons—one of the strangest phenomena of human group biology in all history—told with all essential detail, and authoritatively. The author is of Mormon descent on both sides, his father having been the first settler in the upper Snake River Valley, where he was sent by the Mormon Church to start a colony. Naturally the Mormon philosophy and point of view get sympathetic exposition throughout. At the same time the comic elements that were the ineluctable concomitants of so much sincere earnestness are in no way glossed over. A great part of what is funny about Mormonism and the Mormons came into the picture through Joseph Smith, surely as comic a character as is to be found in all history. Grading A in the truly irresistable combination of humorlessness and concupiscence, and not too queasy about standards of integrity in matters of conduct, he was plainly foreordained to be a religious leader.

With all due admiration for the sterling qualities of the rank and file of the pioneering Mormons, and most of their leaders including especially Brigham Young; and in face of the fact that in the end the whole affair worked out pretty well; the story is nevertheless depressing. It is depressing because it depicts so clearly the ineradicable folly of mankind. How *could* otherwise sensible human beings take seriously the transparently silly rumble-bumble of Joseph Smith? And on the other side, how *could* the people of the United States, and those responsible for the government of the country at the time, treat the Mormons so badly as they did?

The book does not seem to us to rate anything like as high as literature as it does as history. It is too repetitious and tediously verbose. But, at that, it will be a mistake not to read it.

GREENLAND JOURNEY. *The story of Wegener's German Expedition to Greenland in 1930–31 as told by members of the expedition and the leader's diary. Edited by Else Wegener with the assistance of Fritz Loewe. Translated from the 7th German edition by Winifred M. Deans. Blackie and Son, London and Glasgow.* 12s. 6d. net. 8½ x 5⅝; xx + 295 + 47 plates; 1939.

This is the story of the German expedition of 1930–31 to the Greenland ice-cap, planned and led by Alfred Wegener, who died on the ice in the late autumn of the first year, presumably from the failure of an overstrained heart coupled with severe exposure. The primary objectives were geophysical, especially in the realm of glaciology, and climatological. The planning was thorough, and took advantage of much of the wisdom accumulated by the experiences of earlier polar explorers, as well as all the aids that accrue from the development of modern science. But in spite of all this the enterprise did not go well in actual fact. It is not the place here to go into any discussion of the reasons for the succession of mishaps. In spite of the troubles and difficulties the scientific results achieved were more than respectable, both as to quantity and quality. And this popular account abounds in thrills—in fact there were rather more thrills than modern explorers regard as consistent with really well-executed operations in the polar field.

Of specifically biological interest, and also the high point of the enterprise from all points of view, is the account of the winter at *Eismitte*, the station on the

ice-cap at about the center (east and west) of Greenland, where three men lived and made daily observations. Their supplies were inadequate; one of them had to have his frozen and gangrenous toes amputated without benefit of either surgeon, proper instruments, or anesthetic. The Greenland ice-cap in winter must come close to being the world's worst environment for the sustaining of life.

The book is well illustrated, but lacks an index.

TIME-BUDGETS OF HUMAN BEHAVIOR. *Harvard Sociological Studies Volume II.*

By Pitirim A. Sorokin and Clarence Q. Berger. Harvard University Press, Cambridge; Oxford University Press, London. $2.50. 8⅝ x 5⅝; xi + 204; 1939.

This volume embodies the results of a unique investigation on some of the specific activities that constitute human behavior. The main problems with which the study is concerned relate to the kind, frequency and duration of activities that occupy the individual's day, the motivation of the activity, the social elements involved and the influence of sex. The material consists of the systematic records of the activities of almost 100 persons who themselves noted their daily actions for a period of four weeks. The results indicate that in terms of time consumed those activities relating to pleasurable, societal, economic, and physiological needs are the most important; while in terms of the number of persons participating, first place is taken by actions related to physiological needs and then follow those involving economic and societal manifestations. These findings are particularly significant as a demonstration of the multiplicity of factors affecting human behavior and of the importance of those factors that may be called elemental or biological. However, the most interesting aspect of the present investigation regards the analysis of the motivations adduced for the several activities. The most important of all motives is found to be personal comfort, next comes the strictly social motive, while the least frequent appear to be actions based on religious, moral, and legal reasons. These observations reveal clearly the inadequacy of theoretical formulations about social behavior and strongly point to the need for more concrete information about what man actually does and why. The present study represents a successful step in that direction.

MAN THE SLAVE AND MASTER. *A Biological Approach to the Potentialities of Modern Society.*

By Mark Graubard. Covici Friede, New York. $3.50. 9¼ x 6; 354, 1939.

This is a much better book than the rather weak and lukewarm blurbs on the cover would indicate. It is an effort to inaugurate a development of socialism and the social sciences generally that shall be parallel to that now being undergone by psychology, and like it based upon a sound biological foundation.

The author is a thorough going iconoclast, and breaks lances with practically every other modern writer in defense of his own personal philosophy, which he calls scientific humanism. The choice of terminology is unfortunate, for it has little in common with the half dozen or so philosophical systems bearing the same name, which have enjoyed brief periods of efflorescence since the time of Erasmus and which have since disappeared because they lacked strength sufficient to support their own weight. But the philosophy enunciated in this work is thoroughly sound although it contains nothing new. He attacks organized religion while subscribing to many of its tenets.

The author's literary style suggests the exuberance of youth. The verb "to sculpt" fills a long felt need in the English language. (Is this word the invention of the author? It is not in the reviewer's dictionary.) The use of the perfect passive participle of "taboo" in its correct form is to be commended, but the use of "Slovakians" for "Slovaks" is not so happy.

The index covers only five pages, but this is adequate for a popular exposition such as this.

FRONTIERS OF ENCHANTMENT. *An Artist's Adventures in Africa.*

By W. R. Leigh. Simon and Schuster, New York. $3.00. 9 x 6; xi + 299, 1938.

The author, an American painter well known for his realistic portrayals of the out-of-doors, writes in this book of two African expeditions on which he went in the capacity of painter for the American Museum of Natural History of New York. The first expedition was headed by Carl Akeley, great naturist-artist, the practical visionary who first conceived the idea of building African Hall in the Museum of Natural History, famous taxidermist and inventor, author of *In Brightest Africa*, and one of the pioneers in the field of habitat-grouping. It was on this expedition, November 17, 1926, that Carl Akeley died and was buried in the land he loved so dearly. After his death his wife headed the expedition and completed the work which her husband had planned. The author's work on this first expedition as on the second, the Clark-Carlisle Expedition, was that of painting "with perfect fidelity to nature" natural backgrounds for habitat-groups. Wherever he journeyed he painted not the Dark Continent but a glorious, sunbathed, enchanting Africa; not a country of pestilential swamps and jungles but a land of varying natural scenic beauty. In his book Leigh tells of his two expeditions to Africa and manages to convey to the reader, as few writers have before, the "feel" of Africa, an understanding of its animal life and of its wild, virgin beauty. The volume is profusely illustrated with original sketches.

ARCTIC AND ANTARCTIC. *The Technique of Polar Travel.*

By Colin Bertram. W. Heffer and Sons, Cambridge. 7s. 6d. net. 9¼ x 6⅛; xii + 125 + 12 plates; 1939.

This book is different from the usual run of polar travel stories which cite the adventures of a single journey. Appropriately enough the first chapter is entitled "Why?" Why do men go on polar expeditions? With advancing years the reason has changed. It is now largely scientific research—the desire to know. As the principal environmental factor encountered in polar regions is *cold* a number of pages are devoted to the biological effects, on mind and body, of decreased temperature. Clothing, tents and food are dealt with as methods of combating cold. The subject of food, particularly on sledging journeys, is of great importance. In this matter as in that of clothing, recent expeditions are much superior to those of years ago. Not only do the modern rations weigh 25 percent less, but they are definitely better in nutritional value.

One of the greatest problems of polar travel is the type of motive power to be used. The reindeer, the pony, and the mechanical tractor have been tried with mixed success and failure. Man-power and dog-power have proved most efficient, depending upon conditions of the terraine. A multitude of details explain the outfitting of sledging parties, and finally, the writer waxes eloquent over the beauties and calm of polar lands, and the indescribable something that draws explorers away from the activity of civilization.

THE NATIVE RACES OF AUSTRALASIA *including Australia, New Zealand, Oceania, New Guinea and Indonesia. Anthologia Anthropologica. A Copious Selection of Passages for the Study of Social Anthropology from the Manuscript Notebooks of Sir James George Frazer.*

Arranged and Edited by Robert A. Downie. Percy Lund Humphries and Co., London. 35 s. 11 x 8¼; vi + 390; 1939.

The size and numbers of the accounts in this huge volume containing passages from Sir James Frazer's notebooks are apt to frighten the would-be student of social anthropology. Even the most serious student is somewhat appalled at his own insignificance when he considers the statement of the editor that "This volume contains, in the main, material that Sir James has not used in his published works" and then thinks of the prodigious number of books the author has already produced.

The volume is concerned with a very

small portion of the terrestrial globe—merely Australia, Tasmania, the Polyneisan group including among other places New Zealand and the Hawaiian Islands, Micronesia including Formosa and the Philippines, Melanesia including the Fiji Islands and Solomon Islands, New Guinea and the Torres Straits, and Indonesia, in which last group Borneo, Bali, Java, and Sumatra are a few of the places considered. Detailed and numerous passages on the customs and observances of the diverse races of primitive folk of the South Seas are herein presented as first-hand accounts without further explanation. Any interpretation to be made of these facts is left for the reader. An index and five simply outlined maps should aid the student of social anthropoly through this ponderous assortment of manuscript notes.

RED STRANGERS.

By Elspeth Huxley. Harper and Bros., New York and London. $2.50. 8 x 5¼; viii + 406 + 16 plates; 1939.

Although set in the form of a novel—and an entertaining and moving one—actually this volume furnishes in popular form a sound and detailed account of the general and cultural anthropology, as well as the social history over two complete generations of a branch of the Kikuyu people inhabiting the South Nyeri district of the Kikuyu reserve located on the southern slopes of Mt. Kenya in East Africa. It gives a clear picture of the psychological stresses and strains, both individual and social, that accompanied the contact of a native tribe possessing a rather highly organized social structure with the invading whites of the modern world—the Red Strangers. The eventual and inevitable outcome was, of course, the complete subjugation of the blacks, spiritual as well as physical and material. The account makes it clear that, on the whole, the procedures of the whites were as gentle, kindly, and intelligent as could have been expected in the circumstances. And there is no reason to doubt the substantial truth of the impression so conveyed. Yet the net result was to reduce a happy and upstanding people, thoroughly well adapted to an environmental scene to which they had long been accustomed, to a pitiable state. There is apparently no question of the continued survival of the Kikuyu, in the biological sense. It is merely that they will survive as a different sort of human beings.

We recommend this book strongly. It represents an inherently difficult job of writing extremely well done.

TO THE LOST WORLD.

By Paul A. Zahl. Alfred A. Knopf, New York and London. $2.75. 8 x 5½; x + 268 + 16 plates; 1939.

Although the author's expedition through the jungles of British Guiana had a scientific purpose—the finding and capturing of giant poisonous ants (*Paraponera* and *Dinoponera*) to take back to his laboratory at Harvard—this volume is mainly an adventure story and one which is truly exciting and excellently told. Besides the ants which he finally deposited alive before a bewildered customs inspector on a Boston dock, the author's main purpose was to visit the fabled Lost World on top of Mount Roraima far in the uninhabited interior of South America.

Dr. Zahl tells of the thrilling flight from Georgetown in a small hydroplane over dangerous jungles to a point where he and and his companion, a gold and diamond prospector, engaged native guides and carriers and continued on foot and by canoe. During their wanderings through the jungle, the author in search of ants and his companion in search of diamonds which he never found, they encountered natives who had never seen white men, they survived the flood of a tropical river, and visited the gigantic falls both of Kamarang and of the Uitschi, the latter over a quarter of a mile high. They found waterfalls hitherto unrecorded and withstood the dangers of snakes and malaria until at last they scaled the great height of Roraima itself. The volume should be completely enthralling to the adventure lover and to the scientist. The author's excellent and unusual photographs are particularly worthy of praise.

BLACK WORKERS AND THE NEW UNIONS. *By Horace R. Cayton and George S. Mitchell. University of North Carolina Press, Chapel Hill.* $4.00. 9 x 6; xviii + 473; 1939.

By means of numerous personal interviews the authors have inquired into the attitudes of the white worker, the labor union, and the employer towards the Negro worker and the latter's reaction towards the former. The investigation has been limited to three industries—iron and steel, meat packing, and railroad car shops. Both in the north and south the findings appear to be the same. On the part of the white worker there is overt antagonism of varying degree. This appears to be due in part to a persistence of racial intolerance and in part to fear that the Negro will supplant the white. There is some foundation for such fear since in the past the Negro was extensively used as a strikebreaker and in this fashion first made his appearance in Northern industries. The Negro in turn, being well aware of the attitude of the white worker, has reacted by suspecting the motives of his white colleague and has often refused to participate in labor movements. These findings would seem to indicate that among laborers one finds more or less the same barriers to social intercourse between white and Negro as is seen in the general population. This point is, however, not considered at any length by the authors who are more interested in arriving at some means of altering the situation. As a solution they advocate the organization of Negro labor unions which they believe would strengthen the position of the Negro with respect to both the white laborer and to the employer.

THE STORY OF SURGERY. *By Harvey Graham. With a Foreword by Oliver St. John Gogarty. Doubleday, Doran and Co., New York.* $3.75. 9 x 6; 425 + 24 plates; 1939.

Prehistoric skulls have been found which show definite evidences of trepanning, possibly for the release of demons from the body of the victim. Today, in hundreds of wonderfully equipped operating rooms, skilled hands are still struggling against demons. This book is the fascinating story of the progress of surgical knowledge between these two ages. The author mentions other Neolithic evidences of surgery, and then discusses practices among the ancient Chinese, Egyptians, Greeks, and Romans. The art went into eclipse after this, save for a few hardy souls who carried on the teachings of Galen and Hippocrates. A renaissance took place several hundred years later, with the establishment of schools at Salerno and elsewhere in southern Europe. The next few centuries saw the lives of several individuals such as Vesalius, Paré, Clowes, and especially Harvey, who dared question the wisdom of the ancients.

Dr. Graham (a pseudonym) tells how, until the advent of anaesthesia about 1850, the greatest advances were made in the skill and rapidity with which limbs could be amputated or stones removed. After this, speed was no longer at a premium. A few years later came the greatest advance of all—antiseptic surgery. Tribute is paid to Joseph Lister in the story of his life. The book closes with a description of the status of surgery today, and what may be expected in the future.

Dr. Graham writes with all the skill of the dramatist, mingling grim pathos with keen humor. The story is highly recommended to student and layman alike.

TEN YEARS UNDER THE EARTH. *By Norbert Casteret. Preface by E. A. Martel. Translated and edited by Barrows Mussey. The Greystone Press, New York.* $3.00. 8½ x 5½; xx + 283; 1939.

Everybody has longed to view places never before seen by human eyes—ocean depths, polar regions, dense jungles, or underground caverns. One feels, as he reads this book, that he is with the author penetrating the mysteries of grottoes, and chasms. Swimming through submerged tunnels and forcing narrow corridors M. Casteret penetrates deep into the Pyrenees, entering large rooms rich in relics of ages past. He finds prehistoric hearths, flint tools, clay statues, and stone engravings mingled with bones of the now extinct animals with which cave dwellers

had struggled for supremacy. Much of the history of these men and animals is reconstructed from such findings.

Aside from the study of ancient remains, the writer has done valuable work in hydrographic surveying. This involved not only such matters of interest as determining the sources of rivers, but also finding methods of diverting streams for electrical power.

The book is written in an interesting manner, describing vividly all of the conditions met with in subterranean exploration. In some places the caverns are rank with thick slime and decaying carcasses; in others there are colorful frozen lakes, fantastic stalactites and stalagmites, or beautiful flowers of gypsum or other crystals. A section is included on the fauna of caverns. Speleologists and biologists generally will not be alone in enjoying this volume.

JOHN HOWARD (1726–1790) *Hospital and Prison Reformer: A Bibliography.*

By Leona Baumgartner. Introduction by Arnold M. Muirhead. The Johns Hopkins Press, Baltimore. $1.00. 10 x 7; 79; 1939.

John Howard was nearly 50 years of age before he began the work for which he is known. Born in Clapton in 1726 he lived a life of easy routine until his appointment as high sheriff for Bedfordshire. In an attempt to find a precedent for the correction of certain prison abuses, he visited most of the prisons of England and Wales, but found none. The appalling conditions he did find though were carefully recorded in his notebooks. He spent the remaining 17 years of his life, and his fortune, in travel to every country of Europe to study conditions in prisons and lazarettos and died of "camp fever" while inspecting military hospitals at Cherzon, Russia. His two books *State of Prisons* (first edition, Warrington, 1777) and *Lazarettos* (first edition, Warrington, 1789), gave a tremendous, if not immediate, impetus to the improvement of prison and hospital conditions.

Dr. Baumgartner includes in this bibliography not only the editions and translations these two books have passed through, but also works edited by or attributed to Howard, contributions (4) to journals, biography and criticism, contemporary biographical notes and reviews, and unpublished letters. The items are accompanied by interesting notes and in most cases libraries having copies are noted. Dr. Muirhead who acquired the Collection of Howardiana, now in the Library of Dr. John F. Fulton at Yale University, contributes a biographical account of the life and work of Howard.

METHODIK DER VÖLKERKUNDE.

By Wilhelm Mühlmann. Ferdinand Enke Verlag, Stuttgart. RM. 14.(paper); RM. 15.80 (cloth); (25 percent less outside of Germany). $9\frac{3}{4}$ x $6\frac{1}{2}$; viii + 275; 1938.

The spirit of this treatise is essentially emotional. The writer desires a return to ethnology based upon German eighteenth century romanticism. At that time the subject was based upon sophistry and conclusions were drawn from inward feelings.

The writer draws upon a large volume of English, French, and German literature. He endeavors to show that the physical and cultural attributes of men vary among different races. Those races which have developed characteristics giving to them a higher survival value will ultimately become the rulers of less progressive nations. It is an attempt to apply the biological principles of Darwin's natural selection hypothesis to the field of ethnology. It is also pointed out that ethnology is no longer to be regarded as a "pure science" but is to be used as a means of establishing a better *science of life* among individuals in the superior race.

The opus contains an extensive bibliography, and subject and author indexes.

THE CAMEROONS AND TOGOLAND. *A Demographic Study.*

By Robert R. Kuczynski. Oxford University Press, London, New York and

Toronto. $10.00. 9½ x 6½; xviii + 579 + 3 maps; 1939.

This is the first attempt to assemble all the essential facts relating to the collection of population statistics and to the demographic situation of an African area from the beginning of its colonization up to the present time. It is the first part of an analysis which is eventually to be extended to include the Union of South Africa, the Belgian Congo, French West and Equatorial Africa. The West African Mandated Territories were studied first for two reasons: three great Powers, each following a different colonial policy, have participated in their administration; and more ample sources of information were available concerning them, since they were subject to a mandate conferred by the League of Nations. The data for each Territory is treated separately, under each stewardship (German, French, British).

POVERTY AND POPULATION. *A Factual Study of Contemporary Social Waste.*

By Richard M. Titmuss. The Macmillan Co., New York and London. $3.50. 7¾ x 5¼; xxviii + 320; 1938.

That poverty is associated with a high mortality from certain diseases is such a well-known fact that a book describing it would *ipso facto* be considered superfluous, particularly when nothing new is brought out regarding the significance of the association. However, the author's presentation of the English mortality statistics according to geographic regions has for its purpose to emphasize a condition to which insufficient attention has apparently been paid by the powers that be. For some time now, the North of England and Wales have gone through a marked economic depression and there one finds the highest mortality from all causes, from tuberculosis, from puerperal diseases, and from those of infancy, in particular. Furthermore, the decline in mortality noted in the country as a whole has proceeded in these regions with the lowest decrement. The author pleads that something should be done about it, and aside from all humanitarian considerations his simple array of the facts should prove very effective towards this end.

A GUIDE TO ALASKA. *Last American Frontier. John W. Troy, Governor of Alaska, Sponsor.*

By Merle Colby. The Macmillan Co., New York. $3.00. 8 x 5⅝; lxv + 427 + 64 plates + 2 maps; 1939.

The general purpose of the American guide series is to give to Americans a detailed portrait of their country and all its outlying possessions. This volume fulfills its purpose adequately, giving a complete picture of one of our greatest land possessions, namely, Alaska. It gives all the answers to all the questions that an American tourist in Alaska could possibly ask. Included are notes on the history of the discovery and development of Alaska; its purchase by the United States from Russia; its people; its means of transportation and communication; its industries; its points of interest; its climate and its geography. In fact, all that a tourist needs for making the trip to Alaska is this guide, the money, and the inclination to go!

Many illustrations, both graphic and photographic are used to depict the homes, surroundings, and activities of the inhabitants of Alaska. Included also are numerous maps, and a complete index.

RACE RELATIONS AND THE RACE PROBLEM *A Definition and an Analysis.*

Edited by Edgar T. Thompson. Duke University Press, Durham. $3.50. 9 x 6; xv + 338; 1939.

Eight sociologists, an anthropologist and a zoologist—all leading figures in their respective fields—have contributed to this discussion of the problem of intercourse between different racial groups. Almost all the articles are concerned with some aspects of the relationship between Negroes and whites, especially in the south. The articles deal with the differences between the Negroes and whites with respect to natality, mortality, social and economic status, and the kinds of

social relations existing between the two groups. In general the authors stress the question of racial intolerance, the inferior position in which the Negro is held and the probable complications in the Negro-white relations that may arise in the future. In this respect no solution is offered. Although lacking originality with respect to both ideas and discussion, each of the articles represents a scholarly review of the subject treated.

LABOR POLICY UNDER DEMOCRACY. *University of Colorado Studies. Series C. Studies in the Social Sciences, Vol. 1, No. 1.*

By Clay P. Malick. University of Colorado, Boulder, Colo. $1.00. 10 x 6¾; 130; 1939 (paper).

This thorough and comprehensive work is a study of institutions designed to promote industrial peace. The author discusses the democratic state and the significance of government interference and suggests that an adequate method of industrial peace must embody three fundamental principles: The need for strong organizations to represent the interests of employers and employees; legal recognition and enforcement of their collective agreements; and, finally, appropriate agencies for adjusting their differences and for supplying sanctions to the arrangements adopted by them. In addition to the chapter on labor laws in the United States, chapters are also devoted to conciliation in Great Britain, the law of labor in Weimar, Germany, and compulsory arbitration in Australasia. Bibliographic footnotes supplement the pages.

TRACKS IN THE SNOW.

By David Haig-Thomas. Oxford University Press, New York. $3.00. 8 x 5⅝; 292 + 16 plates; 1939.

In this swift moving drama of the north, the reader is carried right along with the explorer, sharing all the thrills and hardships that are a part of a journey in the polar region. As the author himself states, the purpose of the journey was never realized, yet one wonders whether his observations of the northern flora and fauna, and his intimate association with the Eskimos are not as valuable in the world of science as would have been the mapping of a few far-off, little-known frozen pieces of land. A picture is given of the absolute ruthlessness of nature in the far north, and of the struggle for existence of the few forms that have selected this cold and frozen waste as their native habitat.

The book is well supplied with photographic illustrations of the animals, plants and people of the region. Several line maps show the areas traversed by the author and his party.

RACES OF AFRICA. *Revised Edition.*

By C. G. Seligman. Thornton Butterworth, London. 2s. 6d. net. 6½ x 4; 255; 1939.

This little volume (first edition appeared in 1930), issued in the Home University Library Series at a low price, is interesting reading. An authority on ethnology, Seligmann has produced a well-rounded picture of the races of Africa, discussing them both from the anthropological and ethnological points of view, in simple non-technical language. The lay reader with an interest in racial studies will derive much pleasure from this book. It would seem to be well-nigh imperative reading for those desiring a comprehensive understanding of the problems with which present-day Africa is confronted. A number of distribution maps are included in the volume, a list of literature, and an index.

RASSENBIOLOGISCHE UNTERSUCHUNGEN *aus dem hygienischen Institut der medizinischen Fakultät zu Kanazawa. Number 7.*

Edited by Y. Koya. Hygienisches Institut an der medizinischen Fakultät, Kanazawa, Japan. 10⅜ x 7¼; 272; 1939 (paper).

This volume contains a series of papers based on anthropological measurement and growth studies, for the main part on Japanese populations. The first paper, on

the Hida inhabitants, is presented in both German and Japanese by Y. Kato; those on constitutional findings among Japanese school-children, by Y. Koya and T. Takabatake, and anthropometric investigations on the Marshall Islands, by M. Samejima are in German. The last contribution, by T. Takabatake, Y. Kato and T. Fukuda, is a series of tables showing relative head breadths and head lengths. Y. Kato and N. Fukuda are in German. The other contributions are in Japanese but the extensive tabular material is supplied with German headings, thereby making them understandable to readers not familiar with Japanese.

SCIENCE AND SOCIAL CHANGE.

Compiled by Jesse E. Thornton. The Brookings Institution, Washington, D. C. $3.00. 9 x 6; xi + 577; 1939.

This volume contains reprints of approximately fifty papers dealing with some of the aspects of the interrelationships among such fields of intellectual endeavor as biology, engineering, economics and sociology. Included are extracts from the writings of learned men from Karl Pearson and Robert A. Milliken to Walter Lippman and Waldemar Kaempffert. In the majority the articles are products of modern writers, but a few classics, John Stuart Mill for example, are also represented. This anthology may prove useful as a source of quotations for the persons who are overtly preoccupied with the influence of science on society but in general the articles contribute very little to an elucidation of the problem.

FACES WE SEE.

By Mildred G. Barnwell. Southern Combed Yarn Spinners Assoc., Gastonia, N. C. $3.00. 11 x 8½; 112; 1939.

Many people have thought that southern cotton-mill workers live amidst backwoods squalor. It is to banish this idea that this book has been published. Most of the pages are devoted to photographs showing mill folks at work, at school, at home and at play. Interspersed are descriptions of family life, with particular emphasis on the financial status of these people and its vast improvement within recent years. "Steady employment, good wages, ample leisure time, pleasant community life have made of cotton mill workers a people of integrity and character who lead simple, normal American lives, who wonder what part of the South folks are talking about when it's called Economic Problem No. 1."

[Reginald, the Office Boy, who is getting so leftish that he walks sidewise like a crab, says that it is a devil of a note that nobody around this office can spot capitalistic propaganda even when it stinks.]

FAMILY INCOME AND EXPENDITURES. *Pacific Region. Part I, Family Income. United States Department of Agriculture Miscellaneous Publication No. 339.*

By Day Monroe, Marjorie S. Weber, and Helen Hollingsworth. U. S. Department of Agriculture, Washington, D. C. 35 cents. 9⅛ x 5¾; iv + 380; 1939 (paper).

This study was undertaken in 1936 to provide comprehensive data on the way American families earn and spend their incomes. Part 1 of this report presents data on the income for the native-white unbroken families studied in small cities and villages in the Pacific States. Part 2 deals with the distribution of total expenditures, and the relationship between income and expenditures. Over half the study is devoted to appendices which include all the factual data in table form.

RUNNER OF THE MOUNTAIN TOPS. *The Life of Louis Agassiz.*

By Mabel L. Robinson with decorations by Lynd Ward. Random House, New York. $3.00. 8¾ x 5½; [12] + 290 + 8 plates; 1939.

This is the very beautiful story of the life of a great man, told for children by one who knew him personally. It is illustrated with colored plates from Agassiz's works, but there is no index and no documentation. The brief bibliography includes such items as Longfellow's and

Whittier's poems, but it omits the appreciative interpretation by Le Conte.

MAN MAKES HIMSELF.

By V. Gordon Childe. Oxford University Press, New York. $1.75. 7¾ x 5; xii + 275; 1939.

This is an American edition of a well-known work first published in England several years ago and reviewed in these columns in Vol. 12, No. 2, p. 218. The two editions do not appear to differ in any way.

ZOÖLOGY

FIELD BOOK OF ANIMALS IN WINTER.

By Ann H. Morgan. G. P. Putnam's Sons, New York. $3.50. 6¾ x 4; xv + 527 + 26 plates; 1939.

This excellently prepared little volume is the result of many years of keen field observation and painstaking compilation of data regarding all forms of animal life in their struggle to survive the rigors of winter weather. A large number of invertebrate as well as vertebrate organisms are followed through their winter cycle of activity, and the story of their mode of survival from early winter to late spring is told. The author has tirelessly tracked down even the smallest insects to find out something about their winter habitats, their economy, their latest fall and earliest spring activity, and their ways and means of setting up in the business of replenishing their kind for the next season.

There is an abundance of illustrative material, both graphic, photographic, and in color plates. A number of charts showing seasonal cycles of habitat, food, and activity have been included. The list of references for each chapter (each dealing with a single phylum) and the complete index add value to the book as a reference or field guide. The volume will undoubtedly find its way into the hands of a variety of professional and lay users, including the professor of natural history or zoology, the hunter, the trapper, or even the high school boy and girl who have an interest in the living things about them.

NOMENCLATOR ZOOLOGICUS. *A List of the Names of Genera and Subgenera in Zoology from the Tenth Edition of Linnaeus 1758 to the End of 1935.* Vol. I. A-C.

Edited by Sheffield A. Neave. The Zoological Society of London, London. Subscription price for the complete work of four volumes, 8 guineas, post free. 9 x 6¾; xiv + 958; 1939 (paper).

This is an attempt to list alphabetically all the generic names published from the tenth edition of the *Systema naturae* of Linnaeus down to the present day. The editor states in his preface that there are 225,000 entries, and by making allowances for alternative spellings and cross references this number may be reduced to 192,000.

The reviewer who contemplates a work of this magnitude can sympathize with Xerxes standing beside the Hellespont, who is reported to have wept because out of his army of over two million not one would be alive at the turn of the century. Similarly this work will be out of date before it is printed, for the modern army of systematic zoologists are using mass methods of production to encumber the literature of the science with new generic terms at the rate of four or five a day. What systematic science needs is a *Nomenclator* that shall be issued periodically, reporting all new names, and perhaps publishing synonomies and other helpful matter. Such a work might obviate the nuisance of authority citations, by substituting a reference to the issue of the *Nomenclator* in which the name appeared.

This work should earn the undying gratitude of all systematists who take nomenclature seriously.

FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA. *United States Department of Agriculture. Technical Bulletin No. 634.*

By A. C. Martin and F. M. Uhler. United States Department of Agriculture, Wash-

ington, D. C. 40 cents. 9⅛ x 5¾; 157 + 153 plates; 1939 (paper).

FOOD HABITS OF NORTH AMERICAN DIVING DUCKS. *United States Department of Agriculture. Technical Bulletin No. 643.*

By Clarence Cottam. United States Department of Agriculture, Washington, D. C. 30 cents. 9⅛ x 5¾; 140 + 10 plates; 1939 (paper).

Both of these bulletins are based on material from stomach analyses made by the Biological Survey for the past half century. Widespread increase of interest on the problem of duck conservation and restoration has created a demand for knowledge of the food habits of these birds. The first bulletin supplies statistical data on the types of plants consumed. Each plant is described and its range pictured on a map of North America. Identification of the plants is simplified by the inclusion of 153 plates. The propagation and culture of these duck foods for depleted areas and new refuges is also included.

The second bulletin gives the food habits of each duck (except the mergansers), which includes the method of feeding, types of food chosen, food of adults and juveniles, etc. Both of these volumes provide all the necessary information for a sound conservation and restocking program.

PRINCIPLES OF FOREST ENTOMOLOGY. *Second Edition.*

By Samuel A. Graham. McGraw-Hill Book Co., New York and London. $4.00. 9 x 6; xvi + 410; 1939.

This book, in which emphasis is placed on the influence of insects on the forest rather than on the insects themselves, first appeared ten years ago (cf. Q.R.B., Vol. IV, p. 577). Even within such a relatively short period as this it may happen that insects that were once pests have lost their foothold and have either dropped into obscurity or have become innocuous while the formerly unimportant or unknown insects have become widespread pests. The author's main approach, as in the earlier volume, is through a consideration of general underlying principles selecting certain insect species "to illustrate how these principles apply in individual instances." Whenever necessary, sections have been revised, new information is given on various forest insects which have recently become economically important. The chapter on insect abundance and the sections on termites and on bark beetles have been almost entirely rewritten, and the bibliography revised and extended.

OUR SMALL NATIVE ANIMALS. *Their Habits and Care.*

By Robert Snedigar. Random House, New York. $2.50. 8½ x 5⅝; [10] + 308 + 16 plates; 1939.

Most of us have the desire to keep some animal as a pet. Wild animals would frequently be welcomed instead of the usual domesticated kinds but for the fact that they apparently are so hard to keep. Actually their care is no more involved than that which a common house pet entails, provided one uses a little common sense and a little knowledge of natural history. This book provides information for those interested in keeping wild animals whether at home or in a zoo. Since their care is tied up with the habits of the particular species some space is devoted to the behavior of the animal in the wild. Types of food, cages, traps, and methods of handling for the most common mammals, reptiles, and amphibians are described. Since birds cannot legally be caged, methods of feeding and attracting them are mentioned. The author wisely stresses the fact that the owner should always strive to understand the animal's point of view for its reactions, even when the finger is severely bitten.

FURTHER EXPERIMENTS IN THE BREEDING OF OYSTERS (OSTREA EDULIS) IN TANKS. *Fisheries Investigations, Series II, Vol. XVI, No. 4.*

By H. A. Cole. His Majesty's Stationery Office. London. (Obtainable in America from the British Library of Information, 270 Madison Ave., New York). 2s. net. 10½ x 7; 51; 1939 (paper).

This publication describes the method employed and the success obtained by the author in his oyster-breeding experiments made during 1937 and 1938 in large concrete tanks at Conway, North Wales. From the data at hand, there appear to be enormous commercial possibilities in starting the spats on limed tiles in tanks. The larvae can be accelerated in growth and encouraged to settle earlier by controlling the organic food supply of the flagellate protozoa which make up the greater part of the diet of larval oysters.

The relation of temperature to the spawning among ripe females, and to growth of oyster larvae is not clearly understood, but it is thought that a sudden change in temperature, particularly a rise of several degrees, will stimulate both. The general conclusions herein reached point to the fact that the natural supply of oysters may be augmented by hatching and caring for the immature forms in experimental tanks.

THE MIGRATION AND CONSERVATION OF SALMON. *Publication of the American Association for the Advancement of Science No. 8. Edited by Forest R. Moulton. The Science Press, Lancaster, Pa.* $2.00. 10¼ x 7⅞; 106; 1939.

This publication represents the contributions of some nine distinguished investigators in the field of migration and conservation of salmon. It is the first A.A.A.S. publication to be devoted to a purely biological subject.

It is evident that much is yet to be learned about the migration of salmon, but several interesting conclusions have been reached. The first is that the salmon of a given species may in a particular locality represent a more or less distinct entity, for which the term "stock" has been chosen. There are numerous differences between these local stocks, but it is not yet known whether or not these differences are heritable. A second discovery is that salmon return predominantly to the rivers of their origin. Finally, it has been found that proof of any general decrease in the stock of Atlantic salmon is lacking.

THE DISTRIBUTION OF INSECTS, SPIDERS, AND MITES IN THE AIR. *U. S. Department of Agriculture. Technical Bulletin No. 673. By P. A. Glick. Government Printing Office, Washington.* 25 cents. 9⅛ x 5¾; 150 + 5 plates; 1939 (paper).

Vertical exploration of the earth's surface is still in an embryonic state, but several attempts have been made to explore the regions beyond the confines of our two dimensional environment. This bulletin gives the results of insect trapping at high altitudes by airplane. Over 30,000 specimens of insects and their relatives were taken at altitudes ranging from 20 to 15,000 feet. It was found that size, weight, and buoyancy of the insect are involved in the determination of the height at which it was captured. Temperature, intensity of air currents, convection and turbulence were found, among others, to affect the number of insects caught and their dispersal. Collections were made during the day and night in every month of the year and the results of these collecting trips are fully tabulated. The technique employed is also explained and illustrated.

THE WORLD OF INSECTS. *By Carl D. Duncan and Gayle Pickwell. McGraw-Hill Book Co., New York and London.* $3.50. 9 x 6; ix + 409; 1939.

Insects are among the earth's most interesting creatures and the more that is learned concerning them, the more wonderful appears their adaptibility and instincts, their anatomy and physiology, their usefulness and destructiveness, their numbers and kinds. The authors of this book succeed in portraying these characteristic features of insects without resorting to dry scientific terminology. Whenever entomological terms are used they are fully explained and consequently the book reads like a novel, is as interesting as a biography, and as informative as a text. Many illustrations aid in making this a most excellent addition to the general literature on insects.

PROTOZOOLOGY. *Enlarged and completely rewritten edition of Handbook of Protozoology.*

By Richard R. Kudo. Charles C Thomas, Springfield, Ill., and Baltimore. $6.50. 8¼ x 5½; xi + 689; 1939.

This work is advertised as a second edition, but in reality it is a new work. The text has been completely rewritten and expanded to half again its former size, the illustrations are enlarged in size and increased in number, and an improved taxonomy has been employed. Even the name has been changed.

The Mycetozoa, generally claimed by the botanists, are included; if this step is justified the nomenclature should have been modernized, for at least one generic term used in this group has been preoccupied in Mollusca for more than a century. The index covers 47 pages and is very exhaustive.

ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIV, Part 2, Numbers 6–9.*

New York Zoological Society, Zoological Park, New York. $2.25. 10½ x 7; 200 + 11 plates; 1939 (paper).

By far the longest paper in this series is the first (No. 6) on Deep-sea fishes of the Bermuda Oceanographic Expeditions: Family Melanostomiatidae (pp. 65–239, 77 text figures), by William Beebe and Joselyn Crane. The other papers are on The eye structure of the four-eyed blenny, *Dialommus fuscus* Gilbert; Studies on virus diseases of fish. III. Morphological and experimental observations on the lymphocystis disease of the pike perch, *Stizostedion vitreum;* and Studies on lymphocystis disease in the orange filefish, *Ceratacanthus schoepfii* (Walbaum), from Sandy Hook Bay, N. J.

THE CHISEL-TOOTH TRIBE.

By Wilfred S. Bronson. Illustrated by the Author. Harcourt, Brace and Co., New York. $2.00. 8½ x 6; [6] + 200 + 4 plates; 1939.

In this generously illustrated volume, the author attempts to acquaint the young with the habits, appearance, and activities of the many different kinds of rodents. After an introductory chapter on the tribe in general, the author goes on to give the reader personal glimpses into the lives of tree squirrels, ground squirrels, prairie dogs, woodchucks and beavers. Two chapters are devoted to the remarkable feats of the rat and mouse, while the chinchilla, porcupine, and rabbit also have their place. The volume contains much of interest to the young naturalist. The illustrations, in color and black and white, are both attractive and amusing.

TURTLES OF THE UNITED STATES AND CANADA.

By Clifford H. Pope. Alfred A. Knopf, New York. $3.75. 8⅝ x 5⅝; xviii + 343 + v; 1939.

A great amount of labor has gone into the writing of this book, which describes primarily the distribution, habitat, and habits of the 63 species of turtles living in North America and on its shores. Further data are given on anatomy, reproduction, offspring, and rate of growth. As an introductory chapter much information is presented on the lives of turtles in general. Intrinsically interesting as the material is, the writer, in a forced effort to make his book entertaining, frequently indulges in sad witticisms that smell a little. Pictures are abundant and the bibliography is extensive.

THE LITTORAL FAUNA OF GREAT BRITAIN. *A Handbook for Collectors.*

By N. B. Eales. With a Foreword by Stanley Kemp. The University Press, Cambridge; The Macmillan Co., New York. 8½ x 5½; xvi + 301 + 24 plates.; 1939.

This book gives keys to the more common species of creatures to be found in the waters of the British coast. Because the literature on the inhabitants of littoral areas is scattered the author has set out to make it possible for the collector to identify his specimens down to the genus and

in some cases to the species, in this handy manual. Drawings of the morphology of representative specimens of the larger groups help in comprehending the descriptive terms used in the keys. There is an appendix which gives hints on shore collecting, and instructions on preserving material.

INDEX-CATALOGUE OF MEDICAL AND VETERINARY ZOOLOGY. *Part 3. Authors: C to Czygan. U. S. Department of Agriculture. By Albert Hassall, Mildred A. Doss, Marion M. Farr, Gertrude B. Carson and Dorothy Bero. Government Printing Office, Washington.* 40 cents. 9⅛ x 5⅝; 613–961; 1939 (paper).

Hassell and his able assistants have now brought forth the third part (cf. Pts. 1, 2, Q. R. B., Vol. 13, p. 468) of this valuable reference work to medical and veterinary zoology. For those who have the first two numbers, we make the suggestion that there be no delay in obtaining the third since the catalogue is not intended for general distribution and the edition is limited. The price is so very low for each number that the total amount expended when the catalogue is completed will be comparatively small.

KONGO. *The Elephant. By E. Cadwallader Smith. Illustrated by Anne Vaughan. Alfred A. Knopf, New York.* $2.00. 9½ x 6½; [8] + 78; 1939.

Simply and pleasantly told is this story of Kongo—how he was born and grew up in the middle of an African jungle and finally became king of the herd. His adventures, battles and romance should be of more than fictional interest to the young reader as the author has used in his story only elephant facts which have been reliably checked for their accuracy. The illustrations, both in color and black and white, are unusually attractive.

LABORATORY DIRECTIONS IN GENERAL ZOÖLOGY. *Third Edition, Revised. By Winterton C. Curtis and Mary J. Guthrie. John Wiley and Sons, New York; Chapman and Hall, London.* $1.50. 9 x 6¼; xxxiv + 195; 1939.

This edition (cf. Q. R. B., Vol. 9, No. 1 for second edition) has been thoroughly revised, the work in vertebrate embryology extended, a section on heredity and variation (in which experiments on *Drosophila* have been outlined) added and the number of figures increased. The changes have been made to accord with the third revision of the author's *Textbook of General Zoology*.

A CHECK LIST OF NORTH AMERICAN AMPHIBIANS AND REPTILES. *Fourth Edition. By Leonhard Stejneger and Thomas Barbour. Harvard University Press, Cambridge.* 9¼ x 6; xvi + 207; 1939.

This useful check list last appeared in 1933 (cf. Q. R. B., Vol. 9, p. 113). The present edition follows the same plan of the earlier editions but it is larger than the third by about 20 pages. A good deal of new material has been added and some changes in classification have been made.

LIFE HISTORIES OF NORTH AMERICAN WOODPECKERS. *Order Piciformes. Smithsonian Institution. U. S. National Museum Bulletin 174. By Arthur C. Bent. Government Printing Office, Washington.* 50 cents. 9¾ x 6¼; viii + 334; 1939 (paper).

This long and complete study of the North American woodpecker discusses in detail the habits and distribution of over 60 subspecies. Many excellent photographs, a long bibliography and a complete index are included.

BOTANY

BIO-DYNAMIC FARMING AND GARDENING. *Soil Fertility, Renewal and Preservation. By Ehrenfried Pfeiffer. Translated from the German by Fred Heckel. Anthroposophic Press, New York; Rudolf Steiner*

Publishing Co., London. $2.25. 8 x 5½; vii + 220; 1938.

Based on Goethe's concept of the "organic whole" of natural processes, Rudolf Steiner has worked out a system of agriculture which he believes is biologically correct, and therefore economically most profitable. Rotation of crops is involved, but the return to the soil of specially treated manure is the key-note of the system. Instructions for the handling of compost piles, and formulae for the reagents used in preparing manure for its return to the soil, will be furnished by the author upon proper request. A hint as to the nature of these preparations is contained in the following quotation:

> control can be obtained by the use of certain plant preparations which induce the right kind of fermentation. This is done by the use of various plants which have always been employed also as medicinal herbs, such as: camomile, valerian, nettle, dandelion, horsetail, etc. These plants are themselves first put through a long fermentation process, buried at specific depths in the earth in close contact with certain parts of an animal organism. The process can be described by saying that through a kind of hormone influence the fermentation is guided in a definite direction [p. 45–46].

The initial quality of the manure is important; and this is dependent on proper stock feeding, which improves the health of the animals, and in last analysis contributes to the health of man. Crops grown on properly treated soil are of better quality, and in some cases, according to the author, they have had definitely beneficial effects in the treatment of digestive disorders.

CATTLE FODDER AND HUMAN NUTRITION. *With Special Reference to Biological Nitrogen Fixation.*

By Artturi I. Virtanen. Cambridge University Press, London; Macmillan Company, New York. $2.25. 8½ x 5½; 108; 1938.

Investigations on nitrogen fixation in plants has shown that leguminous crops not only transfer soluble organic-nitrogen compounds to the soil, thereby improving its quality and promoting the activity of soil microflora, but also accumulate remarkably large quantities of amino-acids and proteins in their own structure. Legumes are thus in a position to play a decisive rôle in the production of milk, to make it economically profitable and biologically self-supporting. The method for effectively exploiting their value as a cattle feed is one of the most important contributions to animal nutrition in recent years. In four brief lectures, delivered in England in 1937 and now published in book form, the Finnish biochemist Virtanen describes how young and succulent legumes, rich in vitamins and in proteins generally, may be preserved over the winter with only slight nutritive losses. The winter feeding of cattle may thus be improved at reduced cost. With the suggested change in forage production winter milk comes to approach summer milk in its vitamin potency, so that the improvement in cattle feeding is also highly significant for human nutrition. Thus the normal dietary of a people may be made more adequate at the source, winter and summer alike, without the expense of supplementary foods. Evidence accumulates day by day that the Finns are a remarkable people.

THE ECONOMIC BOTANY OF THE KIOWA INDIANS. *As it Relates to the History of the Tribe.*

By Paul A. Vestal and Richard E. Schultes. Foreword by Clyde Kluckhohn. Botanical Museum, Cambridge, Mass. $2.00. 10¾ x 7½; xiii + 110 + 4 plates; 1939 (paper).

The possibility of using the economic botany, both present and past, of a particular tribe or community of natives in studying their migration, their contact with other tribes, their industry, and in general, their success in the business of living, has been grossly neglected up to the present time. This has been true because of the fact that no one person has felt well enough trained in both botany and ethnology to undertake such an enterprise. The authors of the present volume have exhibited excellent team work, and their contribution to the field of ethnobotany will undoubtedly elicit the approval of both botanists and ethnologists.

Some 45 families of plants are listed, together with the different species by their

scientific names and the names which are, or have been at some time, used by the Kiowa Indians. The list includes everything from bear grass (*Andropogon saccharoides*), which is used for tooth-picks, to the horse mint (*Monarda fistulosa* L.), which is dried and powdered and used to rub over the head for headaches, over the body for treating fever, and as a remedy for sore eyes and colds. Chapter V lists these plants according to usage by the Kiowas.

A list of bibliographic references including 58 titles, a group of 4 plates of photographs of several important plants, and a complete index make up the remainder of the volume.

PLANT PHYSIOLOGY. *A Textbook for Colleges and Universities.*

By Bernard S. Meyer and Donald B. Anderson. D. Van Nostrand Co., New York. $4.50. 9 x 6; x + 696; 1939.

Written to aid students, and not, as is usually the case, to impress professors, this text is one of the best elaborated in recent years. The first 60 pages deal adequately, clearly, and simply with the physico-chemical phenomena to be used in the treatment of the subject matter. Continual reference is made to the phases in plant physiology to which the phenomena under discussion apply. The extensive use of many structural formulae and chemical equations will delight those readers chemically inclined. The utilization of many graphs and tables help greatly to make the explanations used completely understandable.

The bibliographies presented at the ends of the chapters, although selected, are extensive. The lists of questions appended to most of the chapters will both aid the student to summarize his reading and will, as put by the authors, act as "a catalysis of class discussion." The addition of a history of plant physiology, however, would have made for a more complete book and given the student a clearer concept of the gradual growth of the subject.

THE ANAEROBIC BACTERIA AND THEIR ACTIVITIES IN NATURE AND DISEASE. *A Subject Bibliography (In Two Volumes). Volume I: Chronological Author Index. Volume II. Subject Index.*

By Elizabeth McCoy and L. S. McClung. University of California Press, Berkeley. $10.00 for the two volumes. 11 x 8¼; Vol. I: xxiii + 295; Vol. II: xi + 602; 1939.

Here in two volumes is a bibliography that has many useful features. The Chronological Author Index lists alphabetically by senior author within each year all articles on anaerobic bacteria available to the compilers. Beginning with 7 theses in 1816, the number of titles per year has grown until, in September 1938, when the bibliography went to press, over 200 articles had appeared in 9 months. The Subject Index presents an organization of the literature on anaerobic bacteria which is interesting in its own right. The subject index outline, covering 6½ pages, has categories for all imaginable phases of bacteriological study. In each sub-section, references are again given alphabetically by senior author within each year. Titles of articles may be found by referring to volume I. Also included are several special indices to the bibliography itself, which are helpful in its use.

DATING PREHISTORIC RUINS BY TREE-RINGS. *General Series, Bulletin No. Eight.*

By W. S. Stallings, Jr. Laboratory of Anthropology, Santa Fe, New Mexico. 50 cents. 9½ x 6¼; 20; 1939.

This is a brief essay on the discovery, development, methodology, and applications of dendrochronology (study of tree-rings). In 1901 Dr. Andrew Ellicott Douglass of the University of Arizona began the study of tree-rings in relation to climatic problems, but it was not until 1914 that the cross-dating or cross-identification of annual tree-ring patterns was applied to the study of archaeology. This method of dating archaeological ruins came about as a by-product of Douglass's interest in climatology. It has subse-

quently proved to be one of the most important contributions ever made to American archaeology. Through this work on tree-ring chronology actual dates for the ruins of the Basketmakers and the Pueblos of the Southwest have been established. The author has very simply and clearly explained the methodology and application of tree-ring study to archaeology. This brochure should serve as an excellent introduction to any further reading in a little-known field. A small but comprehensive bibliography is appended.

MAN AGAINST MICROBE.

By Joseph W. Bigger. Macmillan Co., New York. $2.50. $7\frac{3}{4}$ x $5\frac{1}{8}$; 304; 1939.

To the biologist this book may not seem very fundamental. But the author states that he is writing for the educated layman, and from this viewpoint it is an excellent introduction to microbiology.

After a brief essay on Antony van Leeuwenhoek and his work, the reader is told of the different kinds of microbes, methods of studying them, how man becomes infected, and how the body resists invasion. The second part is an interesting treatise on the history of microbiology from the earliest studies on spontaneous generation to relatively recent work in immunology and chemotherapy. Particular emphasis is placed on the contributions of Koch, Jenner, Pasteur, Metchnikoff, Ehrlich, Bordet, and d'Herelle.

According to modes of transmission of the causative agents, numerous diseases and their epidemiology are discussed. A good index and glossary help to make this a suitable volume for the general reader.

TREES OF THE SOUTH.

By Charlotte H. Green. University of North Carolina Press, Chapel Hill. $2.50. $8\frac{1}{4}$ x $5\frac{3}{8}$; xiv + 551; 1939.

The purpose of writing this volume was, in the words of the author, ". . . to arouse an understanding, and an appreciation of trees, for their beauty, their wonder, and their use." Mrs. Green's love of nature, and her intimacy with living things have given her volumes *Birds of the South* and *Trees of the South* lasting charm and genuine interest.

The present volume begins with a brief description of the parts of a tree and their functions; the flowers, fruits and seeds of a tree; and the uses of trees. There follows a detailed description and classification of some 27 families of familiar southern trees. Each species is described and photographed in its own setting. There are additional photographs of bark, leaf, bud, blossom, etc., that will aid in identifying and classifying each species. A table of contents and a useful index complete this excellent volume.

THE BIOLOGY OF BACTERIA. *An Introduction to General Microbiology. Second Edition.*

By Arthur T. Henrici. D. C. Heath and Co., Boston. $3.60. $8\frac{3}{4}$ x $5\frac{7}{8}$; xiii + 494; 1939.

While this text deals in the main with bacteria, a considerable part of the work has to do with protozoa and fungi and other forms of microbic life. It was designed for the general or nontechnical student who would take but one course in microbiology, or as an introductory course for other students who would be taught particular applications of the science in advanced courses. In the second edition, some revision has been made in almost every chapter; the nomenclature and classification of bacteria have been changed to conform to the fifth edition of Bergey's *Manual*; two new chapters have been added dealing with the effect of environmental factors upon bacteria and with the distribution of bacteria in soil, water, milk, and the human body.

PFLANZENZÜCHTUNG. *Sammlung Göschen Band 1134.*

By Hermann Kuckuck. Walter de Gruyter und Co., Berlin. RM. 1.62. 6 x 4; 125; 1939.

The practical aspects of plant culture are stressed in this small volume. The illus-

trative examples presented for the demonstration of various methods are largely confined to vegetables and cereals. Two short chapters give the essentials of plant pathology and plant physiology which the horticulturist should know. A short selected bibliography, a glossary of the principal technical terms, and an index have been provided.

GROWING PLANTS WITHOUT SOIL. *The A. B. C. of Plant Chemiculture. (Soilless Agriculture, Chemiculture, Water Culture, Hydroponics, Tank Farming, Sand Culture). Including Plant Growth Hormones and Their Use.*

By D. R. Matlin. Chemical Publishing Co., New York. $2.00. 8½ x 5½; [10] + 139; 1939.

This hand-book on plant chemi-culture has grown out of a course given by the author to a class at the Belmont Evening High School in Los Angeles. It is well suited for high school work, or for the man in the street who has chosen this interesting phase of botany for his hobby.

MORPHOLOGY

BASIC METHODS FOR EXPERIMENTS ON EGGS OF MARINE ANIMALS.

By Ernest E. Just. P. Blakiston's Son and Co., Philadelphia. $1.25. 9 x 6; x + 89; 1939.

The author sets forth basic methods for the handling of eggs and spermatozoa of marine invertebrates in experimental embryological investigations. The book, containing the author's notes on his laboratory methods, was written in direct response to the need evinced by embryologists for good, safe laboratory methods such as those used with success over a period of years by an experienced investigator. The author outlines general working conditions and precautions to be followed in the laboratory; the criteria for normal development of marine eggs; general considerations of methods for handling eggs and spermatozoa in the laboratory and specific methods for handling those species which are most often used by experimental embryologists; some methods for preliminary experimental manipulations; and methods of fixation, clearing and imbedding, and staining. There is also an appendix in which the author gives the four classes into which eggs are divided according to the stage of maturation in which fertilization occurs in different species; the summary of means by which experimental parthenogenesis may be elicited in various eggs; and protocols on fixation and staining with iron haematoxylin and safranin. The book is bound in wire-o binding, a convenient form for laboratory use. An invaluable aid to experimental embryologists and cytologists.

FORM- UND STOFFWECHSEL DER GOLGI-KÖRPER. *Protoplasma-Monographien Band 18.*

By Gottwalt C. Hirsch. Gebrüder Borntraeger, Berlin. RM. 28. 8⅝ x 5⅝; xi + 394; 1939.

The problem the author has posed is: What rôle does the Golgi apparatus play through its changes of form and content in the restitution of specific products in the cells? In an attempt to at least clarify some points necessary for its solution, he reviews and synthesizes in this monograph the literature, to which he himself has contributed much. Most of the work discussed at length has been done since the appearance of Jacob's *Das Golgische Binnenapparat* (1927) and G. Hertwig's *Allgemeine mikroskopische Anatomie der lebenden Masse* (1929), which the reader is advised to study, if he has not already done so, before proceeding with the present survey.

A welcome feature is a table of terms used, with definitions or descriptions, the name of the person who coined them, and the date, placed at the beginning of the book. The bibliography runs to about 1900 titles, alphabetically arranged by authors. This is preceded by the literature (authors and dates) arranged by specific organs or tissues. The book is profusely illustrated and adequately indexed.

THE STORY OF A BABY.
By Marie Hall Ets. The Viking Press, New York. $2.50. 12 x 9; 63; 1939.
The Story of a Baby is a very readable book designed for both parents' and children's instruction in the embryology of the fertilized egg, its various stages of development, the birth of the baby, hospital care and homecoming. It was written as a result of the interest evinced by children and adults at the exhibit of human embryos arranged by the Loyola University School of Medicine at A Century of Progress, Chicago, 1933–1934. The author has not only carefully studied the various stages of uterine development, but has also observed living newborn babies in maternity hospitals. Thus, in addition to the author's excellent serially arranged drawings and diagrams of pre-natal development, there are delightful sketches of newborn babies in every conceivable sort of mood.

HUNDERT JAHRE ZELLFORSCHUNG. *Protoplasma-Monographien, Band 17.*
By L. Aschoff, E. Küster, and W. J. Schmidt. Gebrüder Borntraeger, Berlin. RM. 16. 8⅝ x 5½; x + 285; 1938.
This volume, dedicated to Eugen Korschelt in honor of his eightieth birthday, may also justly celebrate the one-hundredth anniversary of cytology. It traces the major milestones in the progress of this science since its impetus in the classic investigations published by Schleiden (1838) and Schwann (1839). Küster reviews the work on the plant cell, Schmidt that on the animal cell, and Aschoff's contribution—almost half of the volume—treats the foundations of Virchow's cellular pathology and its advances. The treatment is necessarily sketchy in parts, but nevertheless the book provides a good survey of the subject. Bibliographies for the separate parts would add to its usefulness. Author and subject indices have been provided.

PRINCIPLES OF DEVELOPMENT. *A Text in Experimental Embryology.*
By Paul Weiss. Henry Holt and Co., New York. $5.00. 8½ x 5½; xix + 601; 1939.
This is an excellent comprehensive study of development for the advanced student of biological sciences. The text is divided into four sections: (1) the phenomena of development; (2) the methods of studying development; (3) the principles of development; and (4) the development of the nervous system. The 130 experiments described in the text are used to clarify textual discussions and may also be carried out in the laboratory by the student. There are numerous illustrations and an extensive alphabetically arranged bibliography.
The sub-title as given above is incomplete as the author also takes up the question of post-embryonic development and analytical methods other than experimental.

SUPERFLUOUS HAIR *and Its Removal.*
By A. F. Niemoeller. Harvest House, New York. $2.00. 7⅜ x 4⅞; 155; 1939.
In this treatise, the woman with superfluous hair is advised not to waste her time or money on so-called cures, but instead to apply herself to its safe and effective removal. This book describes in detail every method and device used in the removal of unwanted hair. Medical products, commercial preparations and home treatments are discussed at length and chapters are devoted to electrolysis, diathermy, and X-rays as well as to shaving, depilatories and other methods in more common use. In the final chapter the author gives the formulae for various home treatments and leaves the bewildered female to fend for herself.

A TEXTBOOK OF ANATOMY AND PHYSIOLOGY. *Sixth Edition, Revised.*
By Jesse F. Williams. W. B. Saunders Co., Philadelphia and London. $2.75. 7½ x 5¼; 607; 1939.
The original plan of this excellent treatise remains unchanged. It presents, for the

student outside of medical schools (nursing, physical education, etc.), a sound integration of the knowledge of human structures and functions so that the essentials of anatomy and physiology can be studied as one subject. The revision has been in the direction of incorporating all recent advances in these fields: Chapters I, II, and III have been considerably reorganized. The summaries and questions at the end of each section and the excellent glossary and index and the illustrations, which number 367 (29 in color), help to make this a most useful guide for teacher and student.

ALLGEMEINE GEWEBELEHRE (*Histologie*). *Sammlung Göschen Band 1133.*

By Erich Ries. Walter de Gruyter und Co., Berlin. RM. 1.62. 6⅛ x 4; 130; 1939.

This small volume of the Göschen series is suitable for student use. The historical treatment (Part I) is brief, emphasis being placed on the new methods discussed in Parts II (general) and IV (special, by type of organ or structure). Part III discusses in thirteen pages the structure and functional phenomena of cells and tissues. A glossary and an index have been provided. The bibliography is confined to a few German and French textbooks.

AN INTRODUCTION TO HUMAN ANATOMY. *Second Edition, Revised.*

By Clyde Marshall. W. B. Saunders Co., Philadelphia and London. $2.50. 8⅝ x 5¼; 388; 1939.

This useful elementary text (cf. mention of first edition, Q.R.B., Vol. 11, p. 243) has been revised so that

> it might better achieve its aim which is to supply in addition to the facts of anatomy, in the narrow sense, a brief account of the functional activities of the different organs and of related problems of practical interest. . . . A number of new figures have been added, and a great many more have been clarified and improved.

PHYSIOLOGY AND PATHOLOGY

NUTRITION AND PHYSICAL DEGENERATION. *A Comparison of Primitive and Modern Diets and Their Effects.*

By Weston A. Price. Foreword by Earnest A. Hooton. Paul B. Hoeber, Inc., Medical Book Department of Harper and Bros., New York and London. $5.00. 9¼ x 6; xviii + 431; 1939.

According to the author, primitive peoples not in close contact with the white man have well-developed mandibulae and little evidence of dental decay, while those primitive peoples that have acquired some of the habits of the white man frequently develop facial malformations and carious teeth. The reason, Price opines, is that when left to himself primitive man adheres to the food habits which centuries of experience have shown to be most satisfactory for all physiological requirements, but when he becomes closely acquainted with the customs of the white man he learns about foods which do not contain all the necessary elements for health. This deduction is based on the premises that malnutrition (avitaminosis especially) attributable to or correlated with the mores of modern civilization is responsible for the prevalence of dental caries. To substantiate his conclusions the author reports some of his observations as well as those of others, comparing the dental state of isolated and modernized subgroups of such peoples as the Swiss, Gaels, Eskimos, North American Indians, African natives, Melanesians, Polynesians, Australian, Maori, and Peruvian Indians. More than by a statistical presentation of evidence the writer reinforces his arguments by the case method. He includes in this book many beautiful photographs of perfect denture in the primitives and of malformed jaws and extensively carious teeth in the modernized. The illustrations are so striking that they resemble the "before and after" treatment advertisements, a fact which together with a marked tendency to overstatement detracts from the strength of the arguments regarding the two main points of the book; viz., (a) the relation of diet to dental decay, and (b) the manifestations

of primitive wisdom in the selection of food. A short bibliography is appended to each chapter and there is a very laudatory preface by Prof. E. A. Hooton.

La Fragilité Osseuse Congénitale (*Maladie de Durante*).

By H. Fulconis. Masson et Cie, Paris. 28 francs. 9 x 6; 134; 1939 (paper).

The problem of congenital bone fragility in man has long been a puzzle to the entire medical profession. It has been found that some case histories of the malady closely follow the Mendelian mechanism of inheritance, while others defy all the known laws of heredity. In some cases the bones have been found broken in the foetus, while in others fragility appears at varying time intervals anywhere from birth to 12 or 14 years of age.

In this excellently prepared treatise M. Fulconis has brought together all the available clinical material on the subject, and to supplement his fundamental conclusions has presented some carefully planned experimental data. From the evidence at hand, it appears that the malady is not connected with the processes of calcification or decalcification of bones, but rather, with faulty material (probably associated with the endocrine complex of the mother) which is built into the bones. The parathyroid and oestrogenic hormones seem to be the ones most concerned. In his experiments, the author fed young rats on the milk of castrated mothers, and they soon developed a condition quite similar to bone fragility in man. This was also the case when the young were fed the milk from partially thyroparathyroidectomized females. These experiments give a hint as to the causes which may be present in the case of the child after birth. The same may be true for the cases where the malady appears in the foetus, though the evidence is not yet clear enough to determine whether the cause lies within the mother, the foetus, or in both.

The text is supplemented by a generous supply of tables, charts and photographs. An extensive bibliography, and an index complete the volume.

The Physical States of Protoplasm at Low Temperatures. *Review and Critical Study. Biodynamica*, No. 48.

By J. Luyet and P. M. Gehenio. Biodynamica, Normandy, Missouri. 9½ x 6½; 138; 1939 (paper).

Luyet and Gehenio in this report make a direct hit against the old definition of a biologist, namely: "a biologist is a man with scientific aspirations but without the necessary mathematical background." They open with a very clear discussion of the four states of matter (gas, liquid, crystal, and glass). The next section of the report deals ably with the so-called, "problem of the wall" used in the study of heat conductivity through a solid. The following divisions deal with freezing and the frozen state, supercooling and the supercooled state, and finally the vitreous state. The authors also point out that the methods of measurement used by physicists in their most exact work are no "open sesame" for the biologist and often give results too coarse for the derivation of exact conclusions.

Many photographs, drawings, and graphs add to the clearness of the points and theories discussed in the text of the report. The effects of low temperature upon protoplasm are reviewed up to 1938. The bibliography is composed of 127 titles.

A College Course in Hygiene.

By K. Frances Scott. Illustrations by William D. Sargent, Margaret J. Sanders. Macmillan Co., New York. $2.50. 10 x 7½; 202 + xxx; 1939.

This course is divided into two main parts: (1) Hygiene as it concerns the individual; and (2) Hygiene as it concerns the group. The former section deals with the anatomy, physiology and psychology of the individual, and the latter with race, environment, communicable diseases, and present-day public health work. The

book is intended to be supplemented by lectures, discussions, and outside reading from the reference list which appears at the close of nearly every chapter. Stress is constantly placed upon the fact that the objective of a course of this type is the realization that health and health habits should not be a constant care or a conscious struggle, but rather, an unnoticed part of our daily routine.

One wonders why all the references are made to the female sex, when the volume is intended for a general college course. One wonders also what the reaction of a lively group of freshman lads would be to the section of the work-book which is devoted to a detailed record of menstruation. These peculiarities of the volume are clear when it is realized that the author is a teacher of physical-education in a girls' college and the book was written for use in her own classes. "Especially for Girls" should have been added to the title.

PHYSIOLOGY OF THE UTERUS *with Clinical Correlations*.

By Samuel R. M. Reynolds. Paul B. Hoeber, New York. $7.50. 9¼ x 6; xix + 447; 1939.

Physiologists are fortunate to have this book appear in print. Within its pages are assimilated the results of experimental research on the uterus carried out by hundreds of workers. These results are critically reviewed by the author who stands in a position in this field to select and criticize the material with competent judgment. We can do no better than to quote from the foreword:

> In this book an important subject is given at last the attention it merits. To many readers the first reaction will be astonishment that so much is known about the physiology of the uterus, for there has been no previous general summary of all this work now laid before us by Doctor Reynolds.
>
> Previously the labor involved in a search for these reports [literature of anatomy, physiology, pharmacology and medicine] has acted as a deterrent and has prevented the investigator and particularly the practitioner of gynecology and obstetrics from profiting adequately from the already numerous and illuminating facts on record.

There are many illustrations and a bibliography of over a thousand references. A work of prime importance.

PRIMITIVE TUBERCULOSIS.

By S. Lyle Cummins. John Bale Medical Publications, London. 10s. 6d. net. 8⅜ x 5½; viii + 213 + 3 plates; 1939.

This account of the incidence of tuberculosis in primitive peoples is concerned mostly with the African Negro and embodies the results of the author's extensive clinical experience as well as the observations of others. The author believes that the high mortality of the Negro from tuberculosis is explained by the lack of immunity.

> The person who has no previous contact with tuberculosis is without the power to resist it. But the power to resist is gained, in ordinary civilized cases, very quickly, because the ancestors have been subjected, during innumerable years, to a process of weeding out. . . . The 'primitive' man, born without the power to resist, has not the advantage of ancestors such as this. . . . Given a quiet life and unlaborious days,. . . he may go on to elaborate a kind of immunity, liable to break down, however, if he chances to be in unfavorable conditions, but sufficient for his wants if he remains in his village.

The elaboration of this view constitutes the substance of this book in which the author discusses also theories on allergy and hypersensitivity. Although the author has made a noteworthy contribution in summarizing interesting material, his inferences for the time being are to some degree speculations.

CLINICAL DIAGNOSIS BY LABORATORY METHODS. *A Working Manual of Clinical Pathology. Ninth Edition, Thoroughly Revised.*

By James C. Todd and Arthur H. Sanford. W. B. Saunders Co., Philadelphia and London. $6.00. 9 x 6; 841 + 12 plates; 1939.

Many changes have been made in this widely used text (cf. mention of the eighth edition in Q. R. B., Vol. 11, No. 1) in order "to make the book more valuable to students, teachers, physicians, and

laboratory workers." Only a few of them can be listed.

In the chapter on the blood, Vogel's old classification of anemias has been omitted, and a reclassification by Ottenberg substituted. Because of its simplicity, the old Westergren method for determination of sedimentation rate is now included. . . . Some of the obsolete procedures in urinalysis have been deleted. Included in the chapter on clinical chemistry is the complete technic of Bodansky for the determination of phosphate and phosphatase, with his tables for calculations; the complete technic of the sulfate method of Power and Wakefield also is included. To the tests for liver function has been added the hippuric acid test. Among the new tests should be mentioned the technic for the determination of serum lipase, the technic for the determination of cevitamic acid and sulfanilamide in blood and urine.

VERHÜTUNG ERBKRANKEN NACHWUCHSES. *Eine kritische Betrachtung und Würdigung. Edited by St. Zuruckzoglu. Benno Schwabe und Co., Basel.* 17 Swiss francs. 10 x 7; 347; 1938 (paper).

Fifteen specialists have collaborated in the preparation of this book designed to outline and critically evaluate the eugenic and medical measures that have thus far been taken in Switzerland and other countries in an effort to prevent those who suffer from hereditary mental and physical afflictions from producing a second generation to which they might pass on these disabilities. The subjects of the chapters include general aspects of the problems; specific hereditary diseases, their mode of transmission and methods of control; methods of sterilization of the male and female; castration, and its effects on the sexual, social and mental attitudes of the patients after operation. With regard to the latter there still seems to be no consensus of opinion. The book concludes with a documentary record of the laws passed in various countries in regard to sterilization and castration. There is a subject index.

GUIDING PRINCIPLES FOR STUDIES ON THE NUTRITION OF POPULATIONS. *Series of League of Nations Publications III. Health 1939. III. 1. Technical Commission on Nutrition. By E. J. Bigwood. League of Nations, Geneva; Columbia University Press, New York.* $1.50. 9½ x 6; 281; 1939.

As is indicated by the title, this monograph outlines the techniques for investigating the food consumption and nutritional status of populations. In the first part the author discusses the methods of estimating the food consumption of nations, families, and individuals, with particular emphasis on household surveys. In the second part Bigwood describes in some detail the several anthropometric, physiological, and clinical procedures for studying the individual nutritional status. Data culled from various sources are used to illustrate the subject matter and in addition an appendix contains reproductions of records used in studies on nutrition. An adequate if limited bibliography is also included.

AN INTRODUCTION TO ANIMAL PHYSIOLOGY. *By W. B. Yapp. The Clarendon Press, Oxford; Oxford University Press, New York.* $3.00. 7¼ x 4¾; xv + 319 + 4 plates; 1939.

The writer of this book states that he is "treading on ground where no English angel has been before me" in attempting to cover in one elementary volume almost the whole range of animal physiology. He warns the student that the use of his book will require thought and common sense. We recommend it especially to those reviewing physiology and desiring a mass of data presented very economically. Many physiological experiments are dissected and the kernels presented for consumption. Illustrations are given where their presence will aid the text. The table of contents and the index are well planned and make for easy access to the body of material present. The list of reading suggestions at the end of the book seems all too brief.

BRUCELLOSIS IN MAN AND ANIMALS. *By I. Forest Huddleson. Contributing Authors A. V. Hardy, J. E. Debono and Ward Giltner. The Commonwealth Fund,*

New York; Oxford University Press, London. $3.50. 9 x 6; xxi + 339 + 35 plates; 1939.

The present volume replaces Huddleson's *Brucella Infections in Animals and Man*, a treatise on methods of laboratory diagnosis. The material in the earlier volume has been revised and to it has been added a discussion of the general clinical aspects of the disease plus much general information concerning *Brucella* and brucellosis both in this country and abroad. Three outstanding authorities have collaborated with the senior author in the production of the book and their combined knowledge and experience has made it an important work for students and teachers of medicine, public health workers, laboratory clinicians, and veterinarians. According to Dr. Giltner, "Brucellosis is perhaps three times as prevalent as was tuberculosis at the time its eradication was begun." In man the mortality is low but the course of the disease is often marked by repeated relapses and it may become chronic. The volume contains a number of illustrations (some colored), graphs and tables, an appendix of case reports, a bibliography of 378 titles and an index.

OSMOTIC REGULATION IN AQUATIC ANIMALS.

By August Krogh. University Press, Cambridge; Macmillan Company, New York. $4.00. 8½ x 5½; 242; 1939.

Krogh calls this review of what is known about the permeability of cells and tissues in water animals a "stocktaking." In any field where observations are plentiful and first principles few such a review is important, and in this field just now it is especially opportune. The scope of the book is somewhat wider than its title indicates. Data on the concentration and regulation of single ions have been included, for it is thought that the active transport of ions through cells into and out of the body fluids brings about osmotic regulation. The material is not arranged to bring out any physiological viewpoint, however; instead the observations are simply catalogued according to the major systematic groupings of the animals on which they have been made. A special chapter is devoted to the osmotic conditions in eggs and embryos.

PNEUMONIA *with Special Reference to Pneumococcus Lobar Pneumonia.*

By Roderick Heffron. The Commonwealth Fund, New York; Humphrey Milford, London. $4.50. 9¼ x 6; xvii + 1086; 1939.

Third in the series of publications coming from the Massachusetts Pneumonia Study and Service, this book gives a comprehensive resumé of the present status of the disease, especially pneumococcus lobar pneumonia, in the laboratory and at the bedside. Though not attempting to be complete in any particular phase of the subject, the author brings into one volume material concerning the inciting agent, the lesions produced, and the clinical aspects of and the factors influencing treatment and recovery. The results of specific therapy in a large series of cases are included. The bibliography extends to over 1400 titles. The study is not only a picture of the current situation, but also a solid foundation for further advances.

LA RECHERCHE DE LA PATERNITÉ PAR LES GROUPES SANGUINS. *Étude Technique et Juridique.*

By Louis Christiaens. Masson et Cie, Paris. 26 francs. 7¾ x 5¼; 108; 1939 (paper).

The first half of this little book brings out the advances made in blood grouping since the initial discovery of Landsteiner. Special emphasis is placed on the inheritance of the blood groups and how the blood reactions of the offspring are related to that of the parents. The practical value of these physiological and immunological discoveries are discussed in the second half wherein the author demonstrates the importance of these facts in the medico-legal field. Progress in the utilization of blood groups as evidence of non-paternity, or maternity, in the law courts of various countries shows that the law has been

rather slow in some. The social implications of these physiological facts are discussed, one country claiming that they are becoming a "prophylactic method against immorality".

MATERNAL CARE AND SOME COMPLICATIONS *The Principles of Antepartum, Intrapartum, and Postpartum Care and of the Management of Some Serious Complications.*

Edited by F. L. Adair. University of Chicago Press, Chicago. $1.50. 7⅝ x 5¼; viii + 194; 1939.

This volume, issued with the backing of the American Committee on Maternal Welfare, Inc., is a handy volume for general practitioners, internes, nurses and students. It combines the two handbooks *Maternal Care* and *Maternal Care Complications*. Except for minor changes the textual material is unchanged. The first section is divided into three chapters: Antepartum, Intrapartum, and Postpartum. The second part is also in three chapters: Emesis and toxemias of pregnancy, Obstetric hemorrhages, Puerperal infections. Both sections are clearly and simply written, with a minimum of technical words. Great emphasis is put on the importance of asepsis. A valuable guide.

DIE PHYSIOLOGIE DES WACHSTUMS UND DER BEWEGUNGEN.

By E. Bünning. Verlag von Julius Springer, Berlin. RM. 18 (paper); RM. 19.80 (cloth). 10¼ x 6¾; vi + 267; 1939.

This second volume of the *Lehrbuch der Pflanzenphysiologie*, edited by E. Bünning, K. Mothes and F. von Wettstein, divides into three parts: physiology of activity change and growth of plants, physiology of their mechanisms of movement, and physiology of irritating effects. Each chapter is provided with a bibliography and there is an index.

The first volume of the series, by Mothes, treated the physiology of plant metabolism. The third, and final volume of the set, in which v. Wettstein will treat the development of plants, is scheduled to appear soon, the war gods willing. The complete work will be a useful addition to the plant physiologist's and biologist's library.

OUTLINE OF PHYSIOLOGY.

By William R. Amberson and Dietrich C. Smith. Illustrations by Norris Jones. F. S. Crofts and Co., New York. $4.00. 10 x 6⅞; vii + 412; 1939.

The teacher will find this an excellent introduction to the study of physiology for the beginning college student. The authors have succeeded in presenting simple but sufficiently comprehensive discussions of the important phases of the subject while formal and technical discussions of complicated points have been avoided. Brief introductory material on modern physical and chemical concepts are included. The 177 figures, many of them original, form an important part of the book. A detailed index is included.

THE GENUINE WORKS OF HIPPOCRATES. *Translated from the Greek by Francis Adams. With an Introduction by Emerson C. Kelly. Williams & Wilkins Co., Baltimore.* $3.00. 10 x 6¾; viii + 384; 1939.

This is by far the best printing that has ever been issued of Francis Adams' scholarly translation in the 19th century of the writings of Hippocrates. Most of the foot-notes with which Adams' translation was so extensively supplied have been deleted so that a more continuous and connected picture of medicine in the Golden Age of Greece might be presented. There is an introduction by Dr. Emerson Crosby Kelly on the little-known life of Hippocrates, the gathering together of his writings, and the authenticity of the works recorded in this book. At the end of the text there are two added sections—illustrations of medical instruments and identifications of them.

HUMAN PHYSIOLOGY. *A Textbook for High Schools and Colleges. Eighth Edition, Revised.*

By Percy G. Stiles. Revised by Gordon C. Ring. W. B. Saunders Co., Philadelphia and London. $2.25. 8¾ x 5¼; 450; 1939.

To Professor Ring (long an associate of the late Dr. Stiles) fell the task of revising this well-known elementary text (cf. 7th edition, Q. R. B., Vol. 12, p. 120). The manner of presentation of the material remains largely as in previous editions since in many of the chapters only minor changes were required. Whenever it has been necessary to include new data, especially in the complex field of hormones and of vitamines, the discussion is in keeping with the elementary character of the book.

A Pulsating Circulation Apparatus for Tissue Cultures, Embryos, and Small Organs. *University of California Publications in Zoölogy, Volume 43, Number 10.*

By J. A. Long. University of California Press, Berkeley. 35 cents. 10⅛ x 6¾; 5 + 1 plate; 1939 (paper).

This two-page paper describes a cleverly devised gadget for producing a pulsating current in the nutritive fluid of tissue cultures, embryos, and small organs being studied under the microscope. The apparatus consists of a series of wells and channels, through which the fluid is made to circulate in a pulsating rhythm by the tapping of a magnetic pendulum on a small rubber tube connected with the channels. The apparatus shows considerable original thinking, ingenuity, and mechanical skill.

La Médecine Expérimentale. *Organe de l'Institut de médecine expérimentale de l'Ukraine. Numbers 1 and 2, 1938 and Numbers 1 and 2, 1939.*

Edited by A. A. Bogomoletz, S. J. Steinberg and M. M. Langer. Ukrainian Society for Cultural Relations with Foreign Countries, Kiev. Nos. 1 and 2, 1938, 3krb. 50 kop. each; Nos. 1 and 2, 1939, 5 krb. each. 9½ x 6⅜; No. 1, 1938, 114; No. 2, 1938, 113; No. 1, 1939, 76; No. 2, 1939, 95; (paper).

This new periodical is devoted to the publication of research in experimental medicine (including, of course, also clinical medicine, biology, bacteriology, physics, chemistry and other fields which are necessary adjuncts) in the Ukraine. In addition to the original articles each number lists the contents of foreign journals received by the editors. The more important papers and publications are reviewed.

Health for 7,500,000 People. *Annual Report of the Department of Health, City of New York for 1937 and a Review of Developments from 1934 to 1938.*

By John L. Rice. Department of Health, City of New York. 9 x 6; 390; 1939.

In this volume is given an elaborate account of the machinery of the Department of Health of New York City. The greater portion of the book is dedicated to a description of the function, budget, and personnel of each section and service. In an appendix are listed the publications of the members of the staff during the year 1937. Included in the present report are also the statistics of births and deaths of the year 1937.

Le Métabolisme de l'Azote. *La Physiologie des Substances Protéiques. II. Dégradation, Synthèse, Métabolisme intermédiaire. Fascicule 1. Le Catabolisme Protidique. Caractères, conditions, mécanismes généraux, agents exécutants et régulateurs. Les Problèmes Biologiques XXIII.*

By Émile F. Terroine. Presses Universitaires de France, Paris. 40 francs. 10¼ x 6¼; xii + [8] + 164; 1939 (paper).

This is one of a series of authoritative summaries of the present state of knowledge on the metabolism of nitrogen. The present number deals with the physiology and chemistry of protein catabolism. The bibliography contains 614 titles.

BIOCHEMISTRY

Annual Review of Biochemistry. *Volume VIII.*

Edited by James M. Luck and James H. C. Smith. Annual Reviews, Inc., Stanford University P. O., Cal. $5.00. 8¾ x 6; ix + 676; 1939.

The editors state in the preface that it is hoped "it will be possible to recognize the deep penetration of biochemistry into physiology by transferring [in the future] to the *Annual Review of Physiology* (cf. mention of Vol. 1, in Q. R. B., Vol. 14, No. 4) much subject matter which, hitherto, the reviewers have felt obliged to include in the *Annual Review of Biochemistry*." Both of these reviews are essential for a well-equipped biological library.

Because of the difficulty of adequately reviewing the greater number of published works in this rapidly expanding discipline, the editors of the present *Review* "have felt driven to the alternative solution—the publication of reviews in which, in the judgment of the authors, the contributions of major significance are critically appraised." The subjects as well as the reviewers (always outstanding authorities) usually change from year to year. Twenty-five subjects are discussed in this volume. It is only possible to mention a few of these, selected at random. K. Linderstrøm-Lang writes on proteolytic enzymes; A. Tiselius on the chemistry of proteins and amino acids; R. W. Jackson and J. P. Chandler on metabolism of proteins and amino acids; E. M. Nelson and C. D. Tolle on fat-soluble vitamins; and C. H. Kellaway on animal poisons. As in previous issues each section is well documented and the volume concludes with useful author and subject indexes.

COMPOSITION AND PROPERTIES OF GOAT'S MILK AS COMPARED WITH COW'S MILK. *United States Department of Agriculture. Technical Bulletin No. 671.*

By J. A. Gamble, N. R. Ellis, and A. K. Besley. U. S. Department of Agriculture, Washington, D. C. 10 cents. 9⅛ x 5¾; 72; 1939 (paper).

This bulletin presents the findings of a group of government investigators concerning the comparative chemical, physical and food properties of goat's and cow's milk. Chemically, the goat's milk was similar to that of Holstein milk in percentage of water, protein, fat, and lactose. The goat's milk was found to have much smaller fat globules than either Holstein or Jersey milk, and a lower curd tension than the cow's milk. The essential differences in vitamin potency between goat's milk and cow's milk were that the former had a slightly higher vitamin B and G potency, and a lower vitamin E potency than the latter.

The report is highly technical, and in consequence, will not be of particular value for the farmer. However, it is a significant contribution to the general field of food analysis, and opens the way for numerous further studies of this type.

THE POISON TRAIL.

By William F. Boos. Hale, Cushman and Flint, Boston and New York. $3.00. 8½ x 5¾; 380; 1939.

Dr. Boos' life-time experience in toxicology has given him a variety of experiences of which he writes with interest and enthusiasm. He tells of his work as a physician in this field, and of his experience as a consultant in the use of poison for industrial purposes and in foods. Of most interest, however, is his work in the field of legal toxicology. In this volume he describes a number of the famous civil and criminal cases of the last twenty years in which he has been an expert witness. The author's case histories and anecdotes of the use and misuse of various poisons make excellent reading. An appendix consisting of three formal reports on toxicological investigations has been included and there is a complete index.

HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Inhaltsübersicht.*

Edited by Emil Abderhalden. Urban und Schwarzenberg, Berlin. 9⅜ x 6¼; 127; 1939 (paper).

This final number, constituting a detailed table of contents, marks the completion

of a monumental piece of editing and publishing. Our warmest congratulations go to editor and publisher. To say that the Abderhalden Handbuch is useful, is understatement. It is indispensable for any broadly organized biological laboratory. While in matters of detail it will, of course, get out of date—indeed in some sections already has—nevertheless it will long remain an invaluable reference work as a whole. It is interesting to note that each single part may be purchased separately. The price of the whole work, in 107 volumes bound in half leather, is RM. 4000.

KURZE GESCHICHTE DER KATALYSE IN PRAXIS UND THEORIE.

By Alwin Mittasch. Verlag von Julius Springer, Berlin. RM. 6.60. 8½ x 5¾; viii + 139; 1939 (paper).

Very little was known about catalysis until about a century ago. In the first few pages of this book a resumé is given of some catalytic reactions observed up to the year 1800. The next decade saw the rise of more definite ideas on the subject, embodied in the works of Döbereiners, Bellani, Faraday, and especially Berzellius.

The chemical theory of catalysis was built up in the middle of the nineteenth century by Horstmann, who experimented in both inorganic and organic chemistry. Later students strengthened its position and added to the knowledge of biocatalysis. The work of Wilhelm Oswald is discussed at length, and later-day studies are briefly presented. There is an extensive index of authors.

ESSENTIALS OF PHYSIOLOGICAL CHEMISTRY. *Second Edition.*

By Arthur K. Anderson. John Wiley and Sons, New York. $2.75. 9 x 5¾; ix + 323; 1939.

In this edition the subject matter has been brought up to date. Many sections have been completely rewritten and new material added. More space has been given to those sections dealing with enzymes (oxidations and reductions), intestinal putrefaction and detoxication, and respiration. The section on carbohydrate metabolism has been completely revised and the chapters on hormones and vitamins largely rewritten. A new chapter on Composition of tissues, covering the important facts concerning the composition of muscle, nervous, epithelial and connective tissue, has been added.

TRAITÉ DE CHIMIE ORGANIQUE. *Tome X. Diacides et Polyacides. Matières Grasses. Dérivés Sulfurés ou Séléniés de la Fonction Acide.*

By H. J. Goudet, R. Padova, F. Salmon-Legagneur. Published under the Direction of Victor Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. $6.45 (paper); $7.10 (cloth). 9¾ x 6⅜; xix + 807; 1939.

This is the eighth part of a 15 volume treatise to appear on organic chemistry. Preceding parts have been noticed in these columns, and like the other volumes, this one maintains the high standard set up by the first seven.

SEX

SEXUAL FREEDOM.

By René Guyon. Translated from the French by Eden and Cedar Paul with an Introduction by Norman Haire. John Lane the Bodley Head, Ltd., London. 15s. net. 8½ x 5½; xiv + 344; 1939.

One cannot help but admire the untiring zeal with which advocates of sexual freedom go about their work. There is no doubt that the subject of sex is spoken of with greater freedom than it formerly was, and even that certain taboos are disappearing. However, it is doubtful if any part of the gradual change is due to this book and numerous others almost identical in subject matter.

The volume contains a lot of tiresome reading under the general topics of the need for sexual freedom, its guiding principles, its message, its practice, sex

relations, and "psycho-physiology of the erotic life."

". . .it is easy to understand that, in both sexes, the pursuit of a partner for amorous dalliance has all the excitement of the chase, being no less full of surprises, disappointments, and triumphs. That, of course, explains its unfailing charm. It is certainly the most captivating of sports."

All those who wish to become members of the Hunt Club kindly turn to page 136 and subscribe to the twelve exalted by-laws.

How to Achieve Sex Happiness in Marriage.

By Henry and Freda Thornton. Vanguard Press, New York. $2.00. 7½ x 5; xii + 155; 1939.

Both to the happily married who wish to avoid "the perils of monotony", and to the unhappily married (sexually), this book offers advice. Variations and new techniques are described for the former, while the latter are given suggestions to awaken their sexual lethargy or to remove any barriers that have arisen which tend to mar their marital pleasures. A new feature that crops up in this far from unique type of book is a discussion of vocabulary and of proper terms to use. [Reginald, the Office Boy, claims, however, that they missed several good ones.] Another feature is that the book is perfectly frank and to the point and should satisfy those who desire their information "straight from the shoulder". Unimaginative married couples are probably the ones who will derive the most benefit.

The Rhythm of Sterility and Fertility in Women. *A Discussion of the Physiological, Practical, and Ethical Aspects of the Discoveries of Dr. K. Ogino (Japan) and Prof. H. Knaus (Germany) Regarding the Periods when Conception is Impossible and when Possible. Sixth Revised Edition.*

By Leo. J. Latz. Latz Foundation, Chicago. $1.00. 6 x 4; vii + 151 + 5 folding charts; 1939.

This little book (published with the approbation of the Church) is now in its sixth revised edition (cf. notice of first edition in Q. R. B., Vol. 8, p. 237) and eleventh printing. It is in three parts: (1) physical aspects, (2) practical aspects, and (3) ethical aspects. The question-answer method, so effective with those who find difficulty in organizing their own thoughts, has been maintained.

The Vaginal Diaphragm: *Its Fitting and Use in Contraceptive Technique.*

By Le Mon Clark. C. V. Mosby Co., St. Louis. $2.00. 8½ x 5⅝; 107; 1939.

Physicians will appreciate this book for the valuable information it imparts concerning the vaginal diaphragm as a method of contraception. The author does not enter into the social or economic aspects of birth control but sticks to the subject as indicated by the title. Physiological and anatomical considerations, methods of examination and fitting, together with a description of the diaphragm itself and of vaginal jellies and creams, are all part of the subject matter. Physicians are told how to instruct the patient to make sure she learns the correct procedures. Over fifty illustrations and photographs complete this comprehensive manual.

Feminine Hygiene in Marriage.

By A. F. Niemoeller. Harvest House, New York. $2.00. 7¼ x 4⅞; 155; 1938.

In this small volume, the author discusses the use and abuse of various medicaments and apparatus in a language simple enough to be interesting and of use to the average woman. Beginning with a description of the female sex organs and the mechanism of menstruation, the author goes on to discuss various female disorders and diseases and their treatment. A chapter on douches, hygiene in pregnancy, and on the menopause have been included. Throughout the author warns against the use of quack patent medicines for feminine ailments.

BIOMETRY

QUANTITATIVE ZOOLOGY. *Numerical Concepts and Methods in the Study of Recent and Fossil Animals. First Edition.*

By George G. Simpson and Anne Roe. McGraw-Hill Book Co., New York and London. $4.00. 9 x 6; xvii + 414; 1939.

This contribution to the methodological literature of biology at once takes a place of the first rank in usefulness and importance. The title would seem to restrict it to the field of zoology, but no biologist should allow himself to be misled by this expression of the modesty of the authors. Botanists, and biologists generally, will find it just as useful and helpful as zoologists, even if the illustrations of methods are drawn chiefly from the data of zoology and paleontology.

The coverage of the elements of modern biometric techniques is ample to meet the needs of any biological worker, and probably will continue to be for a good many years to come. This is evident from the chapter heads: Types and properties of numerical data; Mensuration; Frequency distributions and grouping; Patterns of frequency distributions; Measures of central tendency; Measures of dispersion and variability; The normal curve; Probability and reliability; Sampling; Comparisons of samples; Small samples and single specimens; Correlation; Regression; Association; Graphic methods; Growth.

An Appendix gives practical hints on computation; assembled symbols and formulas used; and a glossary. A selected bibliography and index complete the volume.

The derivations and explanations of the mathematical methods used are painstakingly detailed, and should be crystal clear to anyone, especially as the writing throughout has the charming lucidity that characterizes the senior author's other works.

The book is remarkably, though not completely, free from slips. One should perhaps be mentioned here because it happens to be of just the type likely to mislead the class of persons for whom the book is primarily intended. On p. 14 (footnote) it is stated that:

> The mean of a ratio is most easily calculated by dividing the mean of one set of measurements by the mean of the other, but note that this is not proper unless all the measurements are paired. That is, if, for instance, a mean length:width ratio is sought, it may be obtained by dividing the mean length by the mean width if each length is accompanied by the corresponding width of the same specimen and each width by the corresponding length. This is not always true of paleontological data; and if unpaired measurements have been included in the means of the two primary measurements, the ratio of each individual must be taken and the mean of the ratios then calculated. The difference is seldom significant, but this procedure is technically the correct one.

This clearly implies, if the pairing condition is assumed to have been met, that

The Mean of a Ratio = The Ratio of the Means (of the variables entering the ratio) which is not true. Consider for example the following series of ratios:

10/2 = 5.000000	14/6 = 2.333333
11/3 = 3.666667	15/7 = 2.142857
12/4 = 3.000000	16/8 = 2.000000
13/5 = 2.600000	

The ratio of the means is 13/5 = 2.6, but the mean of the ratios is 2.963265. The difference (0.363265) is not small; it amounts to 13.1 percent of the average of the two quantities entering the difference.

But such minor inadvertences will be cleared up in later editions, that are sure to be rather quickly demanded. For this is a first rate book, that we can recommend highly.

THE CONCEPTS OF THE CALCULUS. *A Critical and Historical Discussion of the Derivative and the Integral.*

By Carl B. Boyer. Columbia University Press, New York. $3.75. 9 x 6; vii + 346; 1939.

It may seem strange to some readers to hear a mathematical treatise referred to as delightful reading, yet that is exactly what this work is. Not that it is simple reading—far from it. It is delightful reading because it is the history of an idea.

The calculus has sometimes been con-

sidered the supreme achievement of the human mind. It has also been said to have been the invention of Newton and Leibniz, but discovery would be a better word. But this is a very loose statement, for while the setting of the keystone may safely be attributed to these two titanic intellects, the cornerstone of the structure had already been laid in the time of Thales of Miletus, more than twenty centuries previously, by the Egyptians and Babylonians. In these pages we meet not only the great mathematicians of antiquity such as Pythagorus, Euclid, Eudoxus, and Archimedes, but also the more catholic philosophers, Plato, Aristotle, Democritus, and Zeno (who must have been great as a humorist as well as a metaphysician), Lucretius, and Plotinus.

The average man thinks of the Dark Ages as a period in which the advance of intelligence became a retreat. In reality they appear dark because our records are incomplete. They were an age of tradition, but they produced such thinkers as Leonardo of Pisa, Nicholas of Cusa, Richard Suiseth, Thomas Bradwardine, Nicole Oresme, Blasius of Parma, William of Occam, and Duns Scotus, to mention a few at random—all of them, men whose names can be mentioned with honor and dignity in any connection. Then came the renaissance of learning with such names as Stevin, Kepler, Galileo, Cavaliere, Torricelli, Descartes, Fermat, and Pascal, the last two of whom just missed making the discoveries that crowned the careers of Newton and Leibniz, who are the first of the strictly modern period, which produced also such men as Gauss, Euler, and Helmholtz. In the pages of this book we meet all these men and many others like them, and learn how they influenced subsequent thought.

The book's documentation is tremendous—several footnotes on nearly every page. There is a bibliography of 25 pages and a finely printed index of 10, but the book suffers by lack of a table of chronology. In a work that approaches its subject from the view point of history a chronological table is almost indispensible and it is unfortunate indeed that one was not compiled in the present instance.

PROBABILITY, STATISTICS AND TRUTH. *By Richard von Mises. Translated by J. Neyman, D. Sholl and E. Rabinowitsch. The Macmillan Co., New York.* $3.75. 8½ x 5½; xvi + 323; 1939.

Between the concept of probability as defined by the mathematician and *a posteriori* probability of the empiricist there exists a logical gap which troubles the mathematical philosopher. In the opinion of many mathematicians probability has yet to be defined in a manner that has practical significance and can serve at the same time as the starting point for the development of systematic rationalization. For this reason a number of definitions have been advanced and among the recent ones is that which Mises introduced almost two decades ago and discusses at length in this book. Mises defines probability as "the limiting value of the empirically observable relative frequency" and on this basis outlines very briefly the fundamental operations and applications of the theory of probability. The major portion of the book is, however, devoted to a defense of his views against the criticism received and a critical examination of the concepts of other mathematicians. Notwithstanding the theoretical nature of the subject and the metaphysical title, the author elucidates the problem and its practical statistical aspects in a better fashion than has usually been done. Particularly interesting are the interpretations of the theorems of Bernoulli and of Bayes in the light of his concepts.

ELEMENTS OF STATISTICAL REASONING. *By Alan E. Treloar. John Wiley and Sons, New York; Chapman and Hall, London.* $3.25. 9 x 5¾; xi + 261; 1939.

Teachers of elementary statistics have come more and more to realize the need of explicitly indicating the logic of statistical procedures as well as the computational technique and theory of the formulae in use. The wisdom of this viewpoint is clearly demonstrated in Treloar's textbook in which, true to the title given it, the author plainly discusses the why and

wherefore of each procedure described. This is the distinctive feature of the present book which in order of exposition does not differ substantially from other elementary texts already available. After a short introduction, the author takes up centering constants, measures of variation and the normal curve. Several well-written chapters on correlation and regression follow. The theory of probability is next briefly discussed and the book closes with chapters on the chi-square test. In an appendix are contained many useful tables that add to the high quality of this as a textbook.

STATISTICAL DICTIONARY *of Terms and Symbols.*

By Albert K. Kurtz and Harold A. Edgerton. John Wiley and Sons, New York; Chapman and Hall, London. $2.00. 7 x $4\frac{3}{4}$; xiii + 191; 1939.

An extremely useful reference book. It gives clear and accurate definitions of about 2,100 statistical terms. Alternative definitions are employed for those terms most frequently encountered in the literature, or where the meaning is difficult to comprehend; also examples are often used for elucidation. During the preparation of the book the authors issued a preliminary edition in mimeographed form which they submitted to an advisory council—a group of statisticians representing "six of the branches of science in which statistical methods find their greatest usefulness"—for criticisms and suggestions.

PRINCIPLES OF THE MATHEMATICAL THEORY OF CORRELATION.

By A. A. Tschuprow. Translated by M. Kantorowitsch. William Hodge and Co., London. 12s. 6d. net. $8\frac{1}{2}$ x $5\frac{1}{4}$; x + 194; 1939.

Most students of statistics are familiar with the German edition of Tschuprow's monograph and therefore will appreciate this good English translation of the work. For the statistical neophyte this represents an excellent opportunity to acquire a real understanding of the logical principles that underly the several measures of correlation, especially as developed by Pearson. Tschuprow's treatment of the subject is distinguished by a simplicity of exposition which emphasizes particularly the difference between stochastic association and functional relationship, and avoids complex mathematics.

METHODS OF STATISTICAL ANALYSIS.

By C. H. Goulden. John Wiley and Sons, New York; Chapman and Hall, London. $3.50. 9 x $5\frac{3}{4}$; vii + 277; 1939.

Some elementary training in statistical theory is presupposed in this textbook. Its emphasis, therefore, is on (a) the design of experiments, following R. A. Fisher's principles, and (b) routine training to familiarize advanced students with practical methods and to give them facility in calculation. The examples and exercises are chosen to be representative of the problems encountered in agricultural research.

WAHRSCHEINLICHKEITSRECHNUNG FÜR NICHTMATHEMATIKER.

By Karl Dörge in collaboration with Hans Klein. Walter de Gruyter and Co., Berlin. RM. 6. 9 x $6\frac{3}{8}$; 113; 1939.

Written to give non-mathematicians an understanding of the underlying principles of the theory of probability, this work loses much in clarity because of the brief treatment given many phases of the subject. Topics discussed include the concept of limits; the concept of probability; series of events; mathematical expectation; means and variation; and the laws of large numbers. The index is too brief and there is no bibliography.

MATHEMATICS FOR ACTUARIAL STUDENTS. *Part I. Elementary Differential and Integral Calculus.*

By Harry Freeman. The University Press, Cambridge; The Macmillan Co., New York. $2.75. $8\frac{1}{2}$ x $5\frac{1}{2}$ inches; vii + 183; 1939.

This standard English textbook on actuarial mathematics has now been divided into two volumes of which the present is the first. With only minor changes this volume reproduces the chapters on trigonometry and elementary calculus that formed part of the previous edition. Succinct but adequate, the exposition is clear and accompanied by well-chosen examples.

PSYCHOLOGY AND BEHAVIOR

MOSES AND MONOTHEISM.

By Sigmund Freud. Translated from the German by Katherine Jones. Alfred A. Knopf, New York. $3.00. 8⅝ x 5⅝; [6] + 218 + vi; 1939.

This is the last book written by Dr. Freud, and the only one during the last six years of his life. It would never have seen the light of publication had the author continued to reside in the city which had been his home for seventy-eight years, but the civilized world can now profit by the sad turn of affairs that compelled him to take up his residence in London only a short time before his death.

The commonly held belief that in this work Freud seeks to prove that Moses was an Egyptian is not strictly borne out by an examination of the work. The birth of the "austere man" of the Pentateuch remains as much of a mystery as his death. What the author attempts to prove is that Moses was a synthetic personality and that one of his component elements may have been an Egyptian. Freud's thesis is that Moses was an Egyptian of high social standing, probably a close friend of Ikhnaton, and a convert to his monotheistic theology; and that when after the death of Ikhnaton the priesthood chiseled his name off the monuments in order to obliterate all memory of him as the first step in the restoration of the polytheistic hierarchy, Moses found it expedient to flee to a border state where he could impose his monotheistic views on the slaves, whom he intended to lead into the desert to establish a monotheistic state. The tribe of Levi, Freud contends, owe their anomalous position in the Israelite political structure to the fact that instead of being the descendants of Levi, son of Jacob, they were in reality the retinue of Moses who had fled from Egypt with him.

The monotheism of Ikhnaton proved too pure for the Israelites to assimilate, and it quickly degenerated into the worship of a tribal deity—the rival of Ashteroth, Baal, Chemosh, and Dagon. The Israelites were forbidden to worship these exotic deities (though they frequently did it) but were not forbidden to believe in them. Freud believes that Moses was murdered by his own followers, and his place taken by a Midianite imposter who assumed the name of Moses.

Psychoanalysis figures widely in the book and the story of the ark in the bullrushes is rejected on psycho-analytic grounds. The ark is symbolic of the uterus, and the Nile of the amniotic liquid. This is an excellent illustration of the weakness of psycho-analysis—it often proves too much. Every human being comes into the world in a figurative ark floating on a figurative Nile. The mental states with which psycho-analysis deals are all interpreted as the representations of forgotten events. And if the representation be symbolic practically any state may be representative of any event. In the present case it is not possible to check back to see what the original events were. The events of early Egyptian and Hebrew history are lost—or rather the records have been tampered with for political purposes so that their original content is no longer recognizable. Freud believes that this condition is sufficient to justify his course of selecting from the evidence that which supports his thesis and ignoring that which contradicts it. This is the weakest point in an otherwise erudite piece of research. There is a glossary and an index, but both are painfully brief.

SLEEP AND WAKEFULNESS *as Alternating Phases in the Cycle of Existence.*

By Nathaniel Kleitman. University of Chicago Press, Chicago. $5.00. 9 x 6; xii + 638; 1939.

As the writer states in his introduction, sleep is often taken for granted as a part

of the routine of life. Everyone of us has to submit to the arms of Morpheus sooner or later, and since the phenomenon of sleep is so prevalent it is obvious that it should attract the attention of mankind and so give rise to numerous speculations as to its nature. Some of these speculations have been idle tales procreated by superstition and ignorance, while others have been based on experimental and observational experience. The author begins his treatise where Piéron in his classical work on sleep in 1913 left off. One may gather the extent of the research done on this problem since that time from the bibliography which contains 1434 titles, none of which appears in Piéron's book.

Sleep is not considered as the opposite of wakefulness, but a complement to the waking state, "the two constituting alternate phases of the same cycle, the one completing the other as the trough of a wave completes its crest." There is not a sharp transition from one phase to the other, but a more gradual transformation.

A list of topics discussed would make a formidable array. Needless to say, there is very little that is missed. The book starts with the functional differences between sleep and wakefulness and progresses through to the final part which is devoted to the theories of sleep. The author describes his interesting experiences in his retreat in Mammoth Cave where he and a co-worker attempted to modify the normal 24 hour rhythm to 21 and 28 hour cycles. Other topics are the pharmacology and hygiene of sleep, hibernation and hypnosis, pathological interferences to the normal sleep-wakefulness cycle, and experimental production and deprivation of sleep.

A useful addition to the literature.

PERSONALITY CHANGES AFTER OPERATIONS ON THE FRONTAL LOBES. *A Clinical Study of 32 Cases. (From the Neurosurgical and Psychiatric Clinics of the Royal Caroline Institute, Stockholm.)*

By Gösta Rylander. Einar Munksgaard, Copenhagen; Oxford University Press, London. Danish Cr. 15.00. $9\frac{5}{8}$ x $6\frac{1}{2}$; 327; 1939 (paper).

A report of a "follow-up" of 32 patients whose frontal lobes had been operated upon during the years 1931 to 1938 in the Neurosurgical Clinic of the Serafimer Hospital in Stockholm.

The main part of these examinations was given to psychiatric research, but, in order to throw as much light as possible on the postoperative condition, consideration was also given to the constitutional and neurological features manifested by the patients. But the chief question to be answered was: "Do mental changes arise after partial excision of the frontal lobes and, if so, of what kind are they?" Of the 32 patients, conforming to certain principles which the investigator deemed essential for his study, 31 had been operated on for tumors, 1 for an abscess; in 20, the operation involved the left frontal lobe, in 12, the right; 12 had a meningioma, 19 a glioma. There was a possibility of an incipient recurrence in 5 cases, although examination revealed signs thereof in only 1 case.

The following changes were found by comparing the mental conditions of the subjects at the time of the follow-up examination with their mental conditions before the onset of the illness:

1. Emotional changes occurred in 30 cases. These changes are revealed in a diminished inhibition of affective responses in 25 cases and in a displacement of the habitual feeling level in 28 cases, in 20 towards euphoria and in 8 towards depression.

2. Changes in volitional and psychomotor activity occurred in 22 cases. 14 patients show restlessness and 12 deterioration of initiative and interest.

3. Intellectual changes, mainly involving the higher faculties, occurred in 21 cases. Specially selected psychological tests were given to all the patients and a control series of 32 non-operated persons. Statistical treatment of the results given shows the existence of significant differences between the two series, the operated subjects doing more poorly in the tests requiring the use of the higher intellectual functions. . . . There does not seem to be any distinct difference between the patients with left-sided and the patients with right-sided lesions.

4. Certain vegetative symptoms were observed but not frequently enough to allow any opinion on their significance.

In conclusion the author states that

Mental changes occur after excision of parts of the frontal lobes. These changes are exhibited in alteration of personality. Generally they are not of such degree as to destroy the subject's ability to lead a normal social existence, but they can be fatal to persons doing qualified intellectual work. . . .

Figures, tables, and a bibliography of 15 plates round out this investigation.

COLOR VISION AND COLOR BLINDNESS IN MONKEYS. *Comparative Psychology Monographs, Volume 15, Number 4, Serial Number 76.*

By Walter F. Grether. The Johns Hopkins Press, Baltimore. 75 cents. 10 x 6¾; 38; 1939 (paper).

In this study the color vision of several species of New World (4) and Old World (9) monkeys was compared with that of man. One of the main purposes of the investigation was to obtain data which would aid in evaluating evolutionary theories of human color vision. Four measures of color vision were made: "discrimination of wave-length differences, proportion of two colors necessary in a complementary mixture, visibility curve, and test for dichromatic vision. Human and monkey subjects were tested under conditions as nearly identical as possible." Among the results obtained are the following:

> Wave-length discrimination of Old World monkeys (a Guinea baboon, a green monkey, a pig-tailed monkey, and five rhesus monkeys) did not differ significantly from that of human beings. Discrimination of three New World cebus monkeys was significantly poorer in the red and yellow regions and about equal in the blue-green region. The discrimination of a New World spider monkey was equal to that of the Old World monkeys.
>
> Compared to the average for three men, all animals tested required a greater proportion of red in a complementary mixture for it to match white. . . .
>
> A test for dichromatic vision, given one cebus monkey, revealed a neutral band in the spectrum at 510 to 520 mμ. This result was taken to indicate that this animal, and probably the other two cebus monkeys also, had dichromatic vision.
>
> Comparison of the color mixture data for cebus monkeys with similar data for human dichromats supported a conclusion that the color blindness of the cebus monkeys conformed to human protanopia (red-blindness).

TYPES, LEVELS, AND IRREGULARITIES OF RESPONSE TO A NURSERY SCHOOL SITUATION OF FORTY CHILDREN *Observed with Special Reference to the Home Environment. Studies from the Center for Research in Child Health and Development, School of Public Health, Harvard University, II. Monographs of the Society for Research in Child Development, Volume IV, No. 2 (Serial No. 21).*

By Eleanor Slater with the Assistance of Ruth Beckwith and Lucille Behnke. Society for Research in Child Development, National Research Council, Washington, D. C. $1.25. 9 x 6; iv + 148; 1939 (paper).

This study is divided into three parts: (1) Responses of young children to the new environment of an observation nursery school (5 chapters). Marked contrasts were observed in the tempo of their activities.

> . . . Two opposite tendencies seemed to be at work . . . . Some children were very high in the number of their responses at the beginning of the period, and the number decreased sharply as the period progressed. Others were very meagre in their responses at first, and the number increased as the strangeness of the situation diminished. . . . Fifteen children out of the original 40 did not follow any simple pattern; they fluctuated from day to day, even from hour to hour, in the tempo of their activities and the nature and number of their responses. They were not a middle group; often they alternated between sharp extremes of activity and inactivity; at least, they showed occasional reversals of behavior.

(2) Responses to specific situations in an observation nursery school (4 chapters), and (3) Irregularities in the levels of response with special reference to changes in home environment (3 chapters). In an appendix are given sample record forms. The statistical data are exhibited in numerous tables and the study concludes with a bibliography of 52 titles.

THE MEASUREMENT OF ADULT INTELLIGENCE.

By David Wechsler. Williams & Wilkins Co., Baltimore. $3.50. 9 x 6; ix + 229; 1939.

The author discusses the reasons why tests standardized on children cannot be used on adults. One of the most fundamental of these is "the fact that adult intelligence cannot be evaluated in the same terms as those generally employed in defining juvenile intelligence."

The contents of the book are in three parts, as follows: Part I, The nature and classification of intelligence. Different phases of this subject are: Nature of intelligence (10 pages); Need for an adult intelligence scale (7 pages); Concept of mental age and I.Q. (17 pages); Classification of intelligence (13 pages); Concept of

mental deficiency (6 pages); and The problem of mental deterioration (17 pages). Part II is concerned with the Bellevue intelligence scales under the chapter headings: Selection and description of tests (29 pages); Population used in standardizing tests (14 pages); Standardization and results (19 pages); and Limitations and special merits (8 pages). Part III gives in detail the manual of Bellevue intelligence tests. In three brief appendices are given statistics concerned with intelligence testing. These are followed by a group of intelligence quotients tables, record blanks, and a brief but well-planned index.

THE BOUNDARIES OF SCIENCE. *A Study in the Philosophy of Psychology.*

By John Macmurray. Faber and Faber, London. 7s. 6d. net. $7\frac{3}{8}$ x 5; 268; 1939.

The author of this work contends that science is limited, by which he means that there is a body of knowledge that cannot be apprehended by scientific method. He calls this body "knowledge of value" and contrasts it with scientifically acquired knowledge, or "knowledge of facts." His argument is that the mind cannot observe itself without prejudice; the observing mind behaves differently from the unobserving mind, therefore the mind cannot learn anything about its own behavior when not under observation. From this innocent premise all sorts of startling conclusions emanate, such as that if a science is true it cannot be true. The author also tells us that the scientist who verifies a theory learns nothing about its truth, but only about its validity. Verbal sophistries such as these have great significance to the metaphysician, but the humble follower of science is likely to feel aghast when they confront him.

Seven pages of index conclude the work.

THUS WE ARE MEN.

By Sir Walter Langdon-Brown. Longmans, Green and Co., New York. $3.50. $8\frac{5}{8}$ x $5\frac{1}{4}$; 244; 1939.

This volume, constituted of a series of lectures, is rather disconnected. The author calls it "Theme and Variations". The theme is that man is finding difficulty in taking the next step in evolution, this step being neither physical nor mental, but psychological. In order to make this advance we must understand the inner workings of the mind. Only in such a way can impulse be ruled, and many of our individual and social problems erradicated. The writer then goes on to deplore the present flight of reason demonstrated by modern music, poetry, and art. He thinks that medicine needs to return to the ideals of Aesculapius. Following this is a discussion of the causes of various types of neuroses.

The second section of the book attempts to analyse the minds of some well-known authors by interpretations of their writings. Closing chapters deal with a variety of subjects, including religion, art, and death.

The writer shows an amazing knowledge of literature, and the volume is well written. However, its principal claim for the attention of the reader lies not in any scientific contribution that it makes, but rather as a study of the author's reflections on life.

LIFE: A PSYCHOLOGICAL SURVEY.

By Sidney L. Pressey, J. Elliott Janney and Raymond G. Kuhlen. Harper and Bros., New York and London. $2.50. 8 x $5\frac{3}{8}$; xxxiii + 654; 1939.

This is a textbook for a new type of introductory college course in psychology. As a background for a survey of problems dealing with the adjustment of the individual to his environment, the authors emphasize our socio-economic and cultural heritage, and the development of the individual both physically and intellectually from childhood to old age. The formal study of psychological principles is left to more advanced courses.

STUDIES OF ABNORMAL BEHAVIOR IN THE RAT. *The Neurotic Pattern and an Analysis of the Situation Which Produces It.*

By Norman R. F. Maier. Harper and Bros., New York. $2.00. 8 x 5¼; [10] + 81 + 16 plates; 1939.

This monograph, a report of experiments on behavior in rats under conditions of frustration, is a description of experimental neurosis in the rat. It is chiefly concerned with the analysis of neurosis-producing situations. A detailed report on the case history of each rat with which the author experimented is included as well as a number of excellent photographs of the subjects.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE FIRST NEGRO MEDICAL SOCIETY. *A History of the Medico-Chirurgical Society of the District of Columbia 1884–1939.*

By W. Montague Cobb. The Associated Publishers, Washington, D. C. $2.15. 7½ x 5; x + 159; 1939.

In 1862 slavery was abolished in the District of Columbia; in 1863 free schools for Negroes were opened; in 1866 Howard University was founded; and in 1868 the School of Medicine of Howard University was formally opened with a student body of eight and a faculty of five. It was from 1869 to almost the turn of the century that qualified Negro physicians made attempts to join the Medical Society of the District of Columbia. However, prejudice was strong in this essentially southern city, and the colored physician was not even professionally recognized by his white brethren, much less admitted into the same medical society. The Negro physicians, feeling that they should be admitted to the Medical Society, had their case brought before Congress and the American Medical Association. Suffice it to say that on one ground or another (not, of course, ostensibly racial) and after much controversy, the Negro physician was not admitted to the Medical Society. Therefore, in 1884, in order to secure for the qualified Negro physicians (as well as for any others qualified to join) the "advantages of regular meetings for medical improvement", the first Negro medical society, the Medico-Chirurgical Society of the District of Columbia, was formed. This society met at irregular periods until 1917 when it became a permanent organization. Today it boasts a membership of 144 physicians out of the 170 in Washington.

The author gives not only particulars concerning the controversy but also tells of the founding of the Negro medical society, its subsequent history to date, and, in general, the status and work of the Negro medical profession in Washington from 1869 on. This report throws light upon the achievements of a small highly-educated group within a minority group set apart by reason of color and bi-racial ideology.

L'HOMME DEVANT LA SCIENCE. *Bibliothèque de Philosophie scientifique.*

By Lecomte du Noüy. Flammarion et Cie, Paris. 20 francs. 7½ x 5; 280; 1939 (paper).

Within the last third of a century revolutionary scientific discoveries have been made. Along with these, the writer claims, have sprung up a number of theories which threaten to become dogmas. He believes that the time has come to subject certain of our concepts to rigid criticism. The principal objection raised is to our atomic theory, which under a rigid materialistic inspection has a number of faults. How can we receive a satisfactory answer to our problems when the basis of our material universe rests on such shallow concepts? The only truly sound basis of science is experimentation with everything expressed in hard and fast mathematical terms.

The writer discusses the problem of the religious and scientific points of view. He says that since neither represents the whole man, one must have a combination of the two.

LONG ISLAND SEAFOOD COOK BOOK.

By J. George Frederick. Recipes edited by Jean Joyce. The Business Bourse, New York. $3.00. 7½ x 5¼; [4] + 324; 1939.

This entertaining and useful treatise, by father and daughter (-in-law presumably),

except for some 25 pages of introductory matter which serves no particularly useful purpose but is harmless, is filled with recipes for cooking seafood of all sorts. Many are excellent—indeed the proportion of bizarre extravagances that are insults to honest fish, crustacea, or molluscs seems definitely smaller than usual in specialist cook books. But we find in the book no sufficiently impressive warning advice against the cardinal sin in nearly all seafood cookery, which is *overcooking*. Because of the prevalence of this obscene and immoral vice few people know the *real* and supernally delicious taste of lobster, for example. It is not in the least like the taste of either leather or rubber.

1939 Britannica Book of the Year. *A Record of the March of Events of 1938. Prepared under the Editorial Direction of Walter Yust. Encyclopaedia Britannica, Inc., Chicago and London.* $10.00. $10\frac{7}{8}$ x 8; 748; 1939.

Prefaced by a calendar of the occurrences in 1938 this volume presents a comprehensive survey of the events of that year in all countries and in all fields of endeavor, from advertising to zoology, alphabetically speaking. It is liberally illustrated with photographs and cartoons. The frontispiece depicting a man with a gas mask entering a safety shelter and surrounded by soldiers and implements of warfare and the principals of the Munich pact, strikes a sombre note to begin with, but happier progress is reported in other matters.

Although this new series of yearbooks is intended to bridge the gap between editions of the Encyclopaedia Britannica, it will be found a permanent as well as timely addition to the library. The volume is indexed.

German-English Science Dictionary *for Students in the Agricultural, Biological and Physical Sciences. First Edition. By Louis De Vries with the Collaboration of the Iowa State College Graduate Faculty. McGraw-Hill Book Co., New York and London.* $3.00. 7 x 5; x + 473; 1939.

This is the most complete handy-sized lexicographical aid to science students that we have seen. The English meanings are well-chosen, specific uses noted, and for most plants and insects Latin as well as common names are given. Abbreviations are included. A selection of words was necessary due to the number of sciences covered, and "not all the names of animals, plants, insects or chemical compounds have been included, since each subject would make a dictionary of its own." There are, however, 48,000 entries.

The one unfavorable criticism of the book we have to make is that the glossy paper on which it is printed is not suitable for long hours of study under artificial light.